Making The Business Case for
Extended Product Responsibility:
A Snapshot of Leading Practices and Tools

Submitted to:
U.S. Environmental Protection Agency
Office of Solid Waste

April 1999

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TELLUS INSTITUTE
Resource and Environmental Strategies

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Any remaining errors of fact or interpretation, of course, are the sole responsibility of the authors.

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EXECUTIVE SUMMARY

EPR in Brief

Extended product responsibility is pollution prevention applied to the product life cycle rather than to the facility. It is the principle that the actors involved over the life cycle of a product — from raw material extraction to disposal; from intermediate goods manufacturers, to manufacturers, distributors, users, and disposal facility operators — share responsibility for the life-cycle environmental impacts of the product.[1]

Examples of EPR activities include product design for life cycle environmental performance; take-back and end-of-life management with particular attention to increased reuse, remanufacturing and recycling; and product stewardship activities. In Europe, take-back and other regulations are mandating elements of EPR in practice. In the U.S., EPR activities have to date been largely voluntary. This report focuses on the voluntary EPR environment.

Environmental benefits of wide spread application of EPR potentially include more efficient use of resources, cleaner products and technologies, more efficient manufacturing, reduced environmental hazard associated with storage, shipping, handling and disposal, improved recycling and recovery, and greener consumption.[2]

Focus: Practices of Leading Companies

The purpose of this paper is to examine the practices of leading companies in combining environmental and cost information to affect EPR decision making and the tools used in assisting this analysis. Section 1 provides an overview of the drivers of EPR and the challenges facing firms that pursue EPR activities. A framework for integrating EPR into product development is presented in Section 2. Section 3 discusses the role and need for EPR decision-support tools, and based upon our assessment of the shortcomings of existing tools, Section 4 provides design recommendations for the next generation of EPR decision-support tools.

Based on the literature and our case study findings, we find that in an environment like the U.S., where pursuit of EPR activities is largely voluntary, the principal drivers to EPR must be direct or indirect economic returns. This business case must be strong; the types of changes EPR demands in firm

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[1] Adapted from University of Tennessee Center for Clean Products and Clean Technologies, *Extended Product Responsibility: A New Principle for Product-Oriented Pollution Prevention*, prepared for the US EPA Office of Solid Waste, EPA 530-R-97-009, June 1997.

[2] *Sustainable America: A New Consensus.* 1996. President's Council on Sustainable Development, February, p 39.

decision-making, product development and operations can be significant, engendering significant internal barriers. Making this business case, however, is difficult. There are significant information-related challenges attendant to integrating environmental and business assessments over the life cycle.

This strongly suggests that EPR decision support tools that lower information-related barriers and provide a framework for assessing the business cases for EPR activities could enhance pursuit of voluntary EPR activities.

Methodology

To evaluate the practices of leading firms, we first conducted research to (1) assess the current state-of-the art in EPR application and (2) to identify firms that have been active in putting EPR into practice in the U.S. (We have maintained a U.S. focus for this report because the regulatory nature of EPR elsewhere establishes a much different set of issues, challenges, and constraints than a company operating in the U.S. faces.)

From this research, we identified a number of U.S. companies that have, in one form or another, put EPR into practice and conducted interviews with nine of these firms. (See Appendix A for interview summaries.) To understand how these companies are applying EPR, what information and tools they use in the decision-making process, and to capture other insights from their knowledge and experience, we developed a questionnaire. The questionnaire served as the framework for telephone interviews we conducted with these firms.

The general research and the interviews shed insight into the challenges posed when firms endeavor to apply EPR to their decision making and how a tool might be positioned to address those challenges.

Principal Conclusions

- For U.S. companies, the primary drivers of EPR efforts are direct and indirect economic returns, sometimes spurred by regulatory pressures. Such returns include direct returns on investments from EPR programs; market advantages through environmental leadership; and advantages resulting from early actions to adapt to regulation in Europe and potential state-level regulation in the U.S.

- EPR considerations are incorporated into product development via product development guidelines., ranging from recycled material content requirements to checklist-based approaches. These guidelines are generally developed by a strategic environmental unit, usually housed within but distinct from corporate EH&S.

- Tools currently available are inadequate to the challenges posed by EPR. A tool that reduces the information-related challenges to making an EPR business case would fill a significant need.

- An EPR decision-support tool should interface with a multitude of staff functions, rather than be more narrowly targeted as, for example, an “environmental” tool or an “accounting” tool.

- The tool should cover unconventional and less tangible costs and revenue impacts. It would not necessarily provide a database function, but would at the very least guide users through a set of questions which form the basis of a comprehensive framework for assessment. It should facilitate comparative decision making between design options and different means of providing the value/service embedded in the product. Current tools largely fail to provide these functions.

- The tool must be flexible — in product types addressed, in breadth of coverage over the lifecycle and the depth of coverage within any one aspect. Achieving this flexibility without the sacrifice of utility and rigor would constitute a significant challenge in tool development. This suggests a modular tool structure wherein the user could decide which module(s) to use based upon the requirements of the analysis being conducted.

1. EPR: CONCEPT AND PRACTICE

EPR Defined

Extended product responsibility is a concept derived from the notion of extended *producer* responsibility, coined in the early 1990s in Sweden.[3] For the purposes of this paper, extended product responsibility refers to the principle that the actors along the product chain share responsibility for the life-cycle environmental impacts of the whole product system, including upstream, production, and downstream impacts.[4]

Examples of EPR activities include:

- product design for life cycle environmental performance;
- take-back and end-of-life management with particular attention to increased reuse, remanufacturing and recycling;
- product stewardship activities.

In Europe, take-back and other regulations are mandating elements of EPR in practice. In the U.S., EPR activities have to date been largely voluntary. This report focuses on the voluntary EPR environment.

What distinguishes EPR from traditional pollution prevention models is that it extends the boundaries of analysis beyond the factory gates. It extends upstream to suppliers and raw materials extractors, and downstream to transporters, retailers, customers, and waste managers. In other words, it applies to the entire product life cycle, as shown in Figure 1. Thus, EPR transforms P2 from a *facility* focus to a *product* focus, thereby capturing impacts upstream and downstream from the factory gates.

[3] Extended Producer Responsibility was introduced by Thomas Lindhqvist of the International Institute for Industrial Environmental Economics for the Swedish Ministry of the Environment in 1990.

[4] Adapted from University of Tennessee Center for Clean Products and Clean Technologies, *Extended Product Responsibility: A New Principle for Product-Oriented Pollution Prevention*, prepared for the US EPA Office of Solid Waste, EPA 530-R-97-009, June 1997.

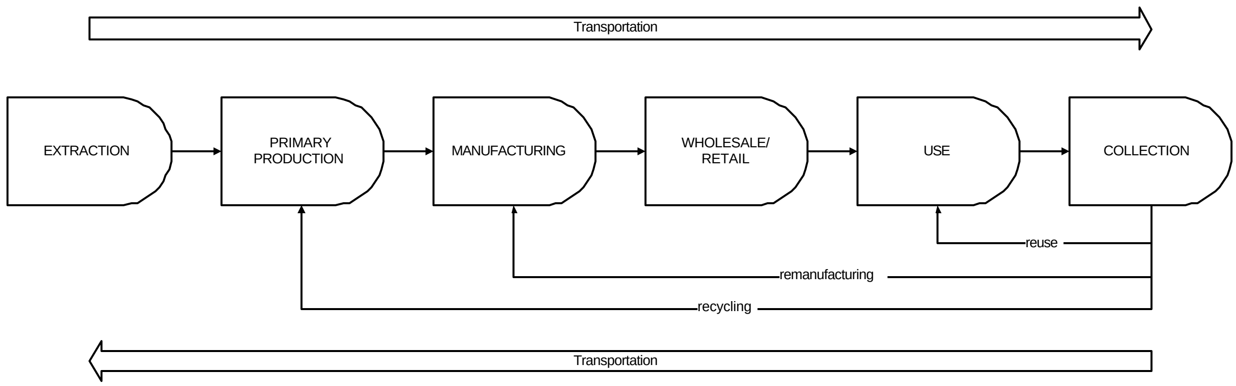

Figure 1: Product Life-Cycle

Decisions that support EPR activities thus need to consider product information from a much broader perspective than is used for typical product decision-making. Standard methods of analysis, even those that incorporate environmental considerations and costs, are usually limited to activities which take place within the boundaries of the firm (e.g., primary production, manufacturing, and wholesale/retail). Missing from the analysis are the costs and environmental impacts relating to other aspects of the product's life cycle (e.g., extraction, use, end-of-life). It is this extension beyond the internal boundaries that defines EPR.

Current EPR Activities

Both in practice and within the definition of EPR we are using for this paper, EPR covers a broad spectrum of activities. A report prepared for U.S. EPA identified general categories of voluntary EPR activity to date. These are detailed in the table below and examples are provided, including those from the activities of the case study companies.

As can be seen, a company's extension of its traditional responsibility can be informational, technical, legal, or physical in nature:

> A report prepared for U.S. EPA[5] suggested the following general categories for voluntary EPR programs.
>
> - Corporate or Industry-Wide Stewardship
> - Take-Back or Buy-Back
> - Leasing Systems
> - Life cycle Management
> - Partnerships for Recycling and Waste Management

[5] *Extended Product Responsibility: A New Principle for Product-Oriented Pollution Prevention*, EPA 530-R-97-009, June 1997.

Category	General Description	Examples
Corporate or Industry-Wide Stewardship Programs	Voluntary measures addressing environmental management systems and downstream environmental and safety aspects of product use (product stewardship)	• Chemical Manufacturer's Association Responsible Care initiative • User training programs (e.g., Monsanto) and site audits (e.g., DuPont)
Take-Back or Buy-Back Programs/ Initiatives	Take-back of product, product components, or packaging for reuse, recycling or proper management.[6]	• Product take-back by Nortel, IBM, and Xerox, among others
Leasing Systems	Ownership of (usually durable) materials and products is retained by the manufacturer or supplier	• Interface's carpet leasing program • Emergent leasing systems for PCs and other electronic equipment
Life Cycle Management	Approaches to product design and development and management which attempt to minimize life cycle impacts of products, typically including working with suppliers and users, and working to incorporate reused or recycled materials	• IBM's Environmentally Conscious Products Program • Nortel's Design for Environment Initiative • Xerox's Environmental Leadership Program
Partnerships for Recycling and Waste Management	Cooperation among companies in the product chain to create common systems for recycling and waste management.	• Rechargeable Battery Recycling Corporation (Ni-Cd rechargeable battery producers) • Vehicle Recycling Partnership (VRP) (Ford, GM, and Chrysler)

Table 1: Voluntary EPR Activity in the U.S.[7]

[6] Examples of mandatory take-back include the German packaging ordinance.

[7] Adapted and paraphrased from *Extended Product Responsibility: A New Principle for Product-Oriented Pollution Prevention.* For more examples, see case studies.

Drivers

EPR decision-support tools should leverage the drivers of EPR and address the key challenges which firms face in pursuing EPR activities. Our case study and background research was directed in part at investigating these drivers and challenges.

What motivates a firm to accept the concept of EPR and voluntarily apply it in practice? In an environment in which EPR activity is voluntary, our research indicated, unsurprisingly, that direct or indirect economic returns are the primary drivers of EPR efforts. Our interviews revealed the following as prominent:

EPR Drivers

- Environmental Leadership for Market Advantage
- Regulation and Potential Regulation
- Economic Return/Better Decision-Making
- Corporate Commitment to Environment

Environmental leadership as market advantage. For some product areas and among certain customers, demand for environmentally preferable products is a reality. This "green demand" might arise as a result of regulatory obligations facing customers, or as a result of their own environmental commitments.

In more general terms, a number of manufacturers are conscious of the perceptions held by many of their stakeholders (customers, communities, suppliers, and investors) that manufacturers avoid bearing the environmental burdens of their own products. These burdens are instead seen to fall upon the stakeholders. These firms believe that significant and valuable good will, cutting across all aspects of the business' management, can be gained by proactive actions to mitigate these impacts.

Regulation and potential regulation. Corporate leaders, particularly product manufacturers, are closely following the development of EPR-related regulation in Europe and proposed state-level regulation in the U.S. Many see an extension of responsibility as an inevitable trend in coming years. Given this belief, failure to prepare now will necessitate costly and hasty reactions when any new requirements come into effect. While regulation may not be inevitable in the US, many firms, especially multinationals, are confronting these regulations in Europe and therefore need to have programs in place. In some cases, this experience demonstrates the value of applying EPR concepts and also sheds light on how it could be pursued in the absence of any regulatory framework.

Measurable economic return/better decision-making. A few firms that have developed the capacity to perform the type of analysis an EPR decision-support tool would facilitate have found specific cases where an EPR-type approach to the life-cycle management of a product is cost effective. In these cases, decision-makers have identified superior economic value comparable to other product strategies. These are the easiest and most compelling types of EPR activities to market internally and generally serve to enhance the perception of the value of EPR.

Likewise, a number of firms have found that the life cycle perspective on product management demanded by EPR leads to better-informed decision-making. Unforeseen liabilities and environmental problems attendant to production and deployment can be minimized through EPR. Life cycle approaches are also seen by some as drivers for continuous quality and efficiency improvements.

Consistency with environmental principles. Many firms that are actively trying to incorporate an EPR framework into their business practices are motivated in part by a desire to substantiate stated environmental principles with action. It is relatively easy to reference sustainable development in a financial or environmental annual report; it is more of a challenge to actualize it. Firms that are making the effort believe that they have some level of obligation to extend the responsibility they bear for their products. These firms often expect or demand a sufficient rate of return from this obligation to render it economically justifiable as well.

Consonant with the responsibility of firms to their shareholders, what these drivers have in common is that firms perceive EPR activities to carry some economic value — explicitly in some cases, intuitively in others. EPR in this context is seen as consistent with, or even as a necessary aspect of, maximizing financial performance. Establishing the business case for EPR is thus the surest incentive to the pursuit of EPR activity. More than this, possessing the *capability* to assess this business case is a prerequisite for any serious *consideration* of EPR activity.

EPR Challenges for the Firm

Why are firms hesitant to implement EPR? Our research and the interviews conducted with companies implementing EPR activities depict a number of real barriers and challenges to its practice. These can be divided into four interrelated categories:

- *Economic viability.* Where EPR — particularly concern for post-manufacturing environmental impacts — is a voluntary practice, an acceptable business case must be made for EPR-based activities and product-related decisions. Challenges to economic viability are challenges to this business case. They concern factors which will (or are perceived to) raise costs and prices under EPR. These might include, for example, costs of a collection system for product take-back, negative customer perceptions of remanufactured and recycled materials, and the inability to pass additional costs incurred along to customers.

- *Internal organizational and institutional issues.* Life cycle environmental impacts have not historically been part of the firm's decision-making related to product design, procurement, manufacturing, packaging and support. EPR considerably expands the scope of factors that enter decision-making and is a significant departure from compliance-focused approaches to environmental issues. It requires integration across firm divisions; it may require a shift from a focus on product provision to a service orientation. EPR effort in one division of the firm may reward actors in another. For example, when designing products with extended life, the cost of original parts is typically increased. The product design group may bear this additional cost while manufacturing receives the monetary credit for the reclaimed product.

EPR and other product stewardship initiatives are often viewed as slowing the product design cycle. In industry sectors where time horizons in translating product concepts to market are short, firms may be hesitant to initiate any activities that impair time to market.

All of this can engender significant internal resistance and points to the depth of cultural change that EPR can demand. In the extreme, some manufacturers may view EPR as nothing more than an attempt to fix responsibility for life cycle impacts on a relatively easy target (themselves). For these companies, there is a firm belief that any sort of EPR approach would be unprofitable and thus unnecessary

- *Technical complexity*. Incorporating life cycle considerations into product-related decisions (including design, procurement, manufacturing and packaging) presents considerable technical challenges, quite apart from the organizational ones described above. These center on the difficulty of conducting LCA-type assessments, and incorporating these assessments into product-related decision-making.

- *External organizational and institutional issues*. EPR involves shared responsibility along the life cycle chain. For manufacturers, this means involvement in aspects of the product life cycle outside the factory gates and the need for closer coordination than previously with upstream and downstream actors (and possibly with competitors). This coordination involves a number of issues, including leverage with suppliers and preserving proprietary sources of competitive advantage. The regulatory environment as it affects reclamation and reuse efforts is also a critical “external” issue.

These barriers and challenges are depicted in the diagram below:

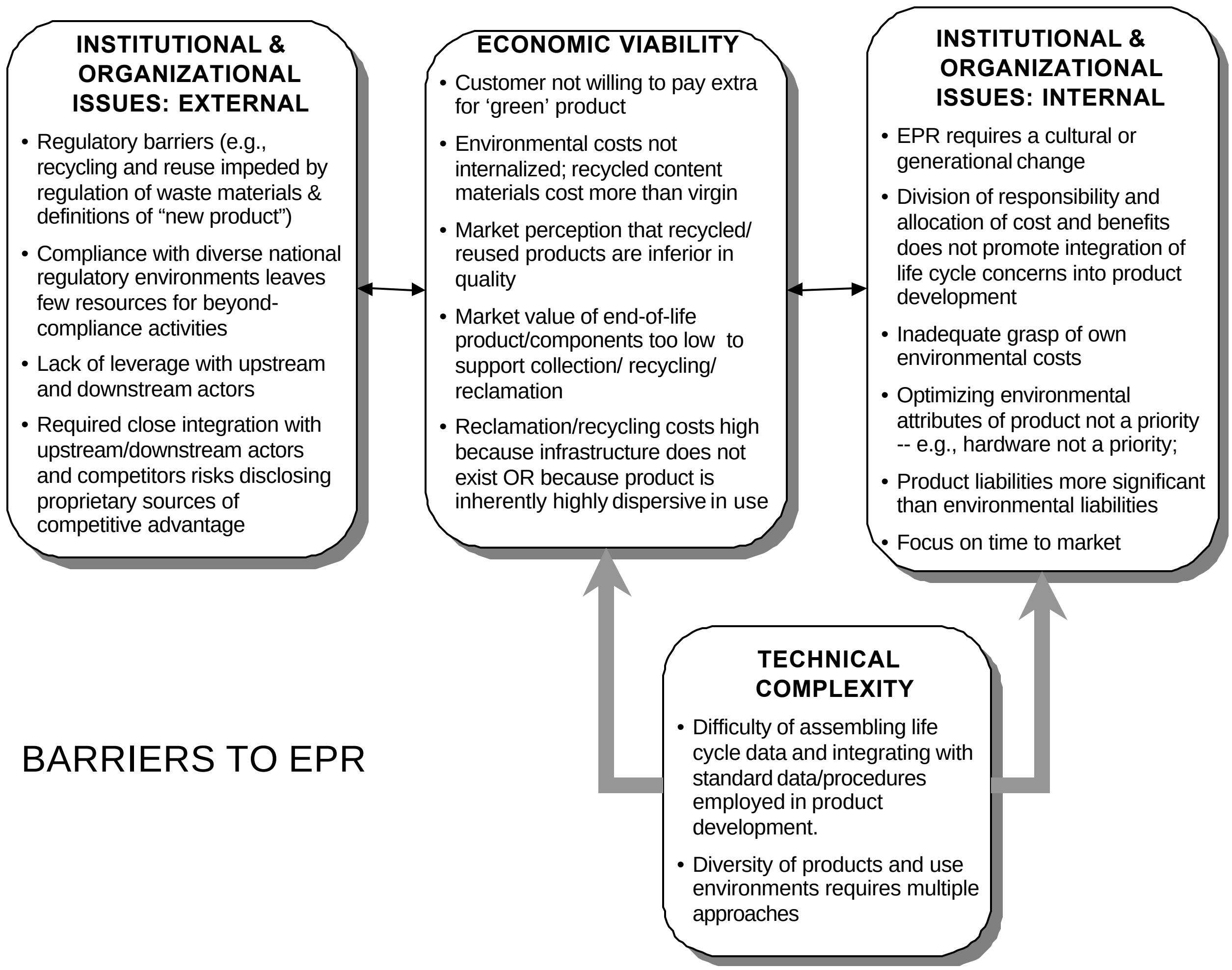

Figure 2: Barriers and Challenges to EPR

Close inspection of these barriers and challenges to EPR underscores the necessity of making the business case and the critical nature of information-based challenges to doing so.

- As already noted, a voluntary environment requires that the economic business case must be made for pursuing EPR activities. Significant internal barriers mandate that this case be particularly strong; many of these barriers manifest as presumptions against the economic viability of EPR activities. This is especially true in the absence of "success stories" — an established record of positive performance for EPR projects.

- The information requirements (technical complexity) of making this case are daunting, both conceptually, and apparently in terms of cost and time. Many firms have difficulty realizing, aggregating, and incorporating the non-environmental costs (e.g., company image, insurance) from their internal manufacturing operations. Taking the next step to try to recognize, assess, and include the environmental and non-environmental costs of activities beyond the factory gates is even more complex. As a result, costs and benefits associated with upstream and downstream impacts are poorly understood and thus rarely included in any product analysis.

  Complexity is further increased because many of the benefits of EPR are expected to be less tangible than the costs — e.g., the value of environmental leadership, anticipation and positioning for future regulation, etc. Their omission, however, obscures consideration of the potential economic and environmental benefits to designing for environment and disassembly, recycling, and remanufacturing.

> <u>The EPR Information Challenge</u>
>
> Information is:
>
> - poorly understood
> - considerably complex
> - seemingly unavailable
> - reluctantly shared

Information-related challenges thus include: complexity and variety of product–user–environment interactions; difficulties in valuing and aggregating environmental impacts and “intangible” benefits; difficulties (i.e., cost and time) of obtaining information; and real and/or perceived risks of information sharing.

Role for EPR Decision Support Tools

From this discussion of EPR drivers and barriers, we have seen that the largest drivers of EPR are perceived economic benefits. At the same time, central barriers to its pursuit are the information-related challenges to making the business case for such benefits. Thus, a decision-support tool that lowers information-related barriers to assessing an EPR business case is likely to significantly enhance the capability and willingness of firms to pursue EPR activities.

Decision-support tools are logical tools to employ towards this end; they essentially facilitate the information management needed to compare alternative courses of action. They may do this in the simplest case by providing frameworks to guide assessment, and in more sophisticated implementations by integrating databases, analytics, and valuation schemes

This does *not* imply that with adequate cost information a business case can always be made for EPR.[8] Nor does it imply that cost information is a panacea for all the barriers and challenges to EPR activities — barriers deriving from the regulatory environment are real, for example, as are the challenges of coordinating with up and downstream actors. However, our interviews with EPR active firms point to a potentially significant contribution that can be made by decision support tools for EPR.

[8] EPR essentially requires that those in the product chain extend their responsibility for a product and assume — internalize — previously externalized costs. While this paper does point to some examples where economic justification for this internalization can be made, there is no reason to believe that this is so in all or even in most situations. There are many costs that relate to environmental impacts of products that are borne by many different stakeholders, including the public at large.

2. EPR DECISION MAKING IN THE FIRM

As discussed in the previous section, EPR programs represent a wide range of activities. EPR decision making correspondingly spans a wide array of decisions — from whether to undertake product take-back to how to design a product, taking into account upstream and downstream environmental impacts. Further, EPR decision-making does not occur within a vacuum; i.e., successful implementation necessitates integrating EPR criteria within the traditional product development processes.

EPR decision support tools should be informed by (1) what full integration of EPR considerations into the product development process ***would require*** of firms in theory and (2) how and to what extent firms ***are actually*** pursuing such integration. Such an understanding provides insights into the potential users and uses of decision support tools.

Framework for Integrating EPR into Product Development

The stages of product-development and deployment are depicted in an idealized way in Figure 3. Regardless of the specific procedures used by particular firms, full integration of EPR into product development and deployment depends in general on the incorporation of three key, interrelated questions into this development process:

- Based on its environmental performance, should we make the product in its current formulation?
- How can we make the product in an environmentally responsible way?
- How can we or others manage the product at the end of its useful life in the most environmentally responsible way?

The relationship of these questions to each stage of the product development process is described below and summarized in Figure 3.

Conceptualization

In this first stage, the idea for the product is generated (either within the firm, or from customer demand), and is screened and evaluated for technical feasibility and acceptance by the customer. A key step within this stage is the business analysis assessing market demand, competition, and profitability of the product. Because this analysis screens out projected unprofitable products, cost data necessary for making the business case for EPR are essential to this analysis. Integration of EPR requires that the first and most fundamental question be asked during this conceptualization stage: *Based on environmental performance considerations, should we make the product in its current formulation?* Except, perhaps, in cases where the product would incur significant liabilities, firms are unlikely to reject a product based solely on its environmental performance and are more likely to alter the product's design to minimize environmental burdens.

A related question is whether the value or function of the product might be delivered in an alternate, environmentally preferable way. This requires a high-level look at the environmental impacts associated with the life cycle of the product: energy and material inputs to manufacturing, manufacturing, use and end-of-life. Evaluating this question thus requires rough consideration of the other two: *how can we make this product, and how can we or others manage it at end-of-life?*

Alternative means of value/function provision include the substitution of a service for the product. A trend towards "servicizing" — that is, replacing a product with a service via leasing, rentals, or flat-fee contract provision — is noticeable in many industries. Examples include Safety-Kleen's leasing arrangement for cleaning solvents and Interface's carpet leasing system. In the automotive industry, companies may contract to provide painted auto parts, rather than paint. Such performance-based incentives reward chemical suppliers for reducing chemical use.

Design, Development, and Manufacturing

During the next three phases of the product life cycle, a prototype of the product is designed, developed and tested. Market testing, wherein the product is tested by the prospective customer/consumer, will inform final design and development before full-scale manufacturing and marketing is launched. Integration of EPR into this stage of the product life cycle requires careful consideration of the second question: *How can we make the product in an environmentally responsible way?*

Design for Environment (DfE) and life-cycle assessment (LCA) are common tools for assessing environmental considerations associated with material and energy inputs to the manufacturing process, as well as downstream manufacturing impacts resulting from design decisions. EPR, however, requires that product design and manufacture consider end-of-life management options as well. There may be clear environmental benefits from extending product life, remanufacturing, or material recycling that have significant implications for manufacturing — e.g., designing for recyclability, ease of disassembly, product upgradability, or increased durability. In some cases, there will be trade-offs between environmental impacts in manufacture and environmental impacts over use and end-of-life. Assessment of "how can we make this product in an environmentally responsible way" thus must be informed by the third and last question: "how can we or others best manage this product at the end of its useful life?"

Support

Planning and implementation of product support is the stage of the product cycle to which the third and final question must be applied: *How can we or others manage the product at the end of its useful life in the most environmentally responsible way?*

EPR efforts to date have focused significantly on end-of-life management — e.g., product take-back and recycling partnerships. Assessment of this question must address the efficacy and environmental benefits of "closing the loop" in ways ranging from material recycling, to remanufacturing and reuse. As noted, alternative end-of-life management options may have significant implications for manufacturing.

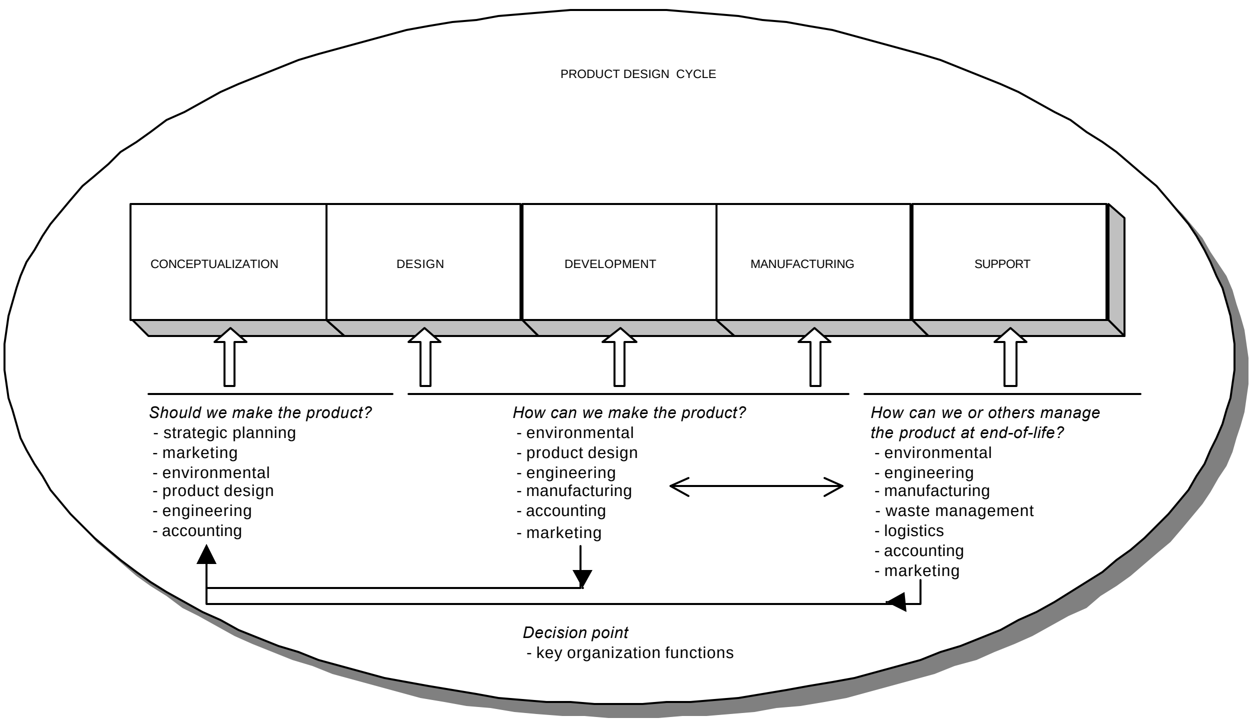

Figure 3. Integration of EPR into the Product Design Cycle

How are Firms Integrating EPR into Product Development?

The previous section presented a framework and general set of requirements for integration of EPR into the product development process. But how and to what extent are firms actually pursuing this integration?

Our interviews with EPR-active firms revealed common elements in the implementation of EPR within the product development process. (Note that the firms themselves generally used terms other than EPR — including, for example, life cycle management, product stewardship, environmentally conscious products.)

- EPR considerations are incorporated into product development via what can generally be called EPR-related product development guidelines. These take a number of forms, ranging from recycled materials content requirements to checklist-based approaches.

  These guidelines were almost always developed by a strategic environmental unit, usually housed within but distinct from corporate EH&S. This unit played an internal advocacy role in a number of our case study firms, attempting to "sell" EPR within the larger organization, including to upper management.

- The degree to which EPR is integrated in product development depends on the means by and rigor with which these guidelines are applied to the development process. Degree of integration and means of guideline application varied significantly among the case study firms. Application ranged from hard requirements and approval processes — e.g., for recycled materials content — to suggested checklists of environmental design considerations.

  Most firms have a "gated" development process in which products must pass a review before moving from, for example, design to development. In a number of cases these reviews provided the forum to assess the conformance of the product and the development process to EPR guidelines.

- Internal resources to support EPR aspects of product development are also provided. These range from an internal consultancy network, to a dedicated group or division providing support and analysis, to the provision of tools that may be employed by the design team.

  Provision of LCA information and costing is typically problematic to these EPR-active firms due to technical complexity and difficulty in obtaining complete data.

- Sharing elements of both resource support and guideline application are several actions which attempt to provide long-run or fundamental integration of EPR concerns into the product development process. These include required training of design staff in environmental design issues, and placement of environmental specialists on integrated design teams. These actions were not common to all the firms included in our interviews.

- Though processes differ significantly between firms, product development is a prioritized, strategic concern for innovation or technology-driven firms. There is no case in which there is not significant high-level involvement in this process. The degree of high-level involvement in development and application of EPR guidelines differs significantly, however. Firms in which EPR was more tightly and thoroughly integrated into the product development process were those firms in which there was clear upper management commitment to life cycle approaches to product development.

Against the idealized picture described in Figure 3, the EPR-active firms in our example generally do not make a strategic decision on product provision. Exceptions involve instances where potential product liabilities are extraordinary. Most EPR decision-making to-date has been based on product design questions, and on life cycle management. Thus, currently EPR decision-making focuses on two of the three decisions points, i.e., *how can we make the product* and *how can we or others manage the product at end of life.* S*hould we make the product in its current formulation* (e.g.., can we replace this product with a dematerialized service?) is rarely addressed, although several of our interviewed firms suggested that such a question should enter the EPR decision making calculus.

3. ROLE AND NEED FOR EPR DECISION-SUPPORT TOOLS

Prior sections of this report describe the process for integrating EPR considerations into product design and development, and, in broad terms, the information-related challenges to assessing a business case for EPR activity. Integrating this information, we now turn to a more detailed description of the information-related challenges firms face in implementing EPR and ways that decision support tools may address these challenges. This information is summarized in Table 2.

Information-Related Challenges to EPR

Source of complexity: Diversity of sources, uses, and dispositions. Upstream and downstream from a manufacturing facility, products create environmental impacts across many media, they are in contact with and interact with many different parties, and their disposition at any point in time is uncertain. Further, the costs associated with their impacts can be widely variable (e.g., disparate landfilling costs in different regions of the U.S.).

Although the practice of EPR does not necessarily demand formal life-cycle assessment, it does pose similar, difficult questions regarding valuation and aggregation. How can impacts in different media be compared? What are the environmental costs associated with different impacts?

Further, impacts and their costs will vary depending on how a material or product is shipped, how long it is used, and how it is disposed of or collected. Assumptions regarding these matters are thus critical, and the basis upon which they should be made is frequently not obvious.

As described in Figure 3, making the business case for EPR requires input from various staff functions — marketing, environmental, product design, manufacturing, engineering, and accounting — amongst others. Collecting the necessary data within and across these often disparate functions can be challenging.

Decision support tools can reduce apparent complexity by providing a framework for assessment. While the integrated business and environmental analysis which EPR demands is complex, even the simplest tool could reduce complexity and enhance understanding by providing a systematic framework for analysis and guiding a user through a sequence of steps. Such a framework would:

- increase awareness and comprehension of life cycle impacts by prompting decision-makers to think through the life cycle impacts of a product in a systematic way
- simplify information processing within and between divisions of the firm by providing a means to organize information

- potentially allow users to narrow the scope of assessment by identifying the largest sources of impacts and points of leverage.

Likewise, methodologies to apply costs to a diverse range of impacts in a consistent manner could facilitate the development of a more complete cost picture for making the business case for EPR.

Difficulty obtaining information. Again like LCA, EPR assessments are troubled by the difficulty of gathering useful information. Data may be housed in many different places (both internal to the firm and external) and many different formats (books, databases, conversations, etc.) and be measured in many different units of measurement and time, if they are available at all. Missing data often requires some form of estimation (e.g., engineering, actuarial, probabilistic, etc.). Further, raw data often demand significant manipulation, synthesis, and consolidation before they become useful information.

Directly associated with this challenge is the time and cost of information gathering. The actual or perceived cost and time to gather and process data can be prohibitively high in today's lean, quick time-to-market corporate environment. Incorporating an EPR approach may seem conceptually attractive, but a source of unacceptable delay in product deployment.

Information availability could be addressed in a few ways:

- Creation of/tool linkage to a data warehouse containing basic, generic cost data on materials, impacts across different media, and various disposition options. Such a database would of necessity be both living and non-comprehensive. Some available LCA tools provide these type of data.

- A second path would be to direct users toward likely data sources, acting as a resource guide. This more open structure would allow for integration with company's internal and external data sources, and would rely on these means to enhance data availability.

- Provide algorithms for estimating upstream and downstream costs/impacts for which there are no data available.

Risks of information-sharing, real and perceived. Assessing product life cycle impacts requires access to information from other upstream and downstream actors in the supply chain. In addition, firms need to share their own information with these same sources. Information-sharing is problematic for two reasons: (1) by providing data regarding environmental impacts, firms are concerned that they are creating a potential liability; and (2) providing these type of data could become a competitive disadvantage as it provides insights into costs and production processes. In both cases, progressive companies that lead the field in the sharing of information may be sensitive to disclosure risks that laggards will not only avoid but perhaps benefit from.

The risks involved with disclosing information will not be easily mitigated since they stem from deep-seated perceptions about privacy, competitiveness, and self-sufficiency and are embedded in many corporate cultures. Indirectly, a decision-support tool could allay these concerns by providing a framework in which firms will see value in both providing and receiving information because it will provide the capacity for them to make better-informed decisions. A decision-support tool might also be able to preserve anonymity of source, if its information is compiled from a number of different firms in a sector. Such an approach is being used by nine large chemical process-based manufacturers (including SmithKline Beecham, and Monsanto, two of our case study firms) to develop a total cost accounting tool for chemical process-based manufacturers. Tool development includes pooling cost data from participating firms to provide a more complete and benchmarked data set than one firm could generate internally.

Assessing real, but less tangible benefits. Among the drivers that motivate firms to adopt EPR principles are enhancements to corporate image and commitment to environmental principles. The economic value of these benefits to the firm is often acknowledged in theory, but rarely if ever quantified. Even more concrete drivers such as competitive advantage are difficult to predict and measure for inclusion in a product analysis.

While less tangible costs will remain somewhat elusive, a decision-support tool might facilitate their consideration by either providing lists of possible less tangible costs and questions to prompt for their consideration. A more sophisticated approach might provide estimation algorithms and/or empirical data from which estimates of less tangible costs and benefits could be derived.

Challenge	*Ways in which a tool might address this challenge*
Diversity of sources, uses, and dispositions.	Reducing apparent complexity by providing a framework for assessment.
Difficulty, cost, and time of obtaining information.	Addressing information availability by: • Creating a linkage to a data warehouse • Directing users toward likely data sources, acting as a resource guidance. • Estimation algorithms for upstream and downstream costs/impacts for which there is no data available
Risks of information-sharing, real and perceived.	Possible mitigation of some information-sharing issues by providing a framework in which firms will see value in both providing and receiving information. By compiling information from a number of different firms in a sector, anonymity of source could be preserved.
Assessing "intangible" benefits.	Facilitating consideration and valuation of intangibles by providing lists of possible less tangible costs and questions to prompt for their consideration or providing estimation algorithms and/or empirical data from which estimates of less tangible costs and benefits could be derived.

Table 2: Addressing Information Challenges

Assessment of Existing Tools

Identifying a role for an EPR decision-support tool says little about the degree to which such a role is filled by existing tools. Certainly, a large number of tools exist which are explicitly intended to aid the incorporation of environmental costs and considerations into private sector decision-making regarding product offerings, or may be employed to such ends.

Assessing these existing tools against the requirements of decision support for EPR requires an understanding both of the different categories of costs tools may incorporate and of the nature of the tasks to which the tools are suited.

Categories of costs are summarized in Table 3, below.

Conventional costs	Items such as capital and equipment, materials, energy/utilities and labor which are usually addressed in cost accounting and capital budgeting.
Potentially hidden costs	Costs that are not readily identifiable because they are often hidden among other items (such as overhead accounts). Maintenance and the costs of downtime often fall into this category. Environmentally related costs in this category include regulatory compliance costs (monitoring, permitting, site preparation, closure) as well as costs voluntarily assumed (R7D, recycling). This category may also include costs associated with company image, community relations,. These are sometimes also referred to as less-tangible costs.
Contingent costs	Potential expenses (including penalties, fines, future liabilities, cost overruns, and market risk) that may be incurred at some future time. Contingent environmental costs include the costs of remedying and compensating for future accidental releases of contaminants into the environment (e.g., oil spills), fines and penalties for future regulatory infractions, and future costs due to unexpected consequences of permitted or intentional releases. Note: "Contingency" is almost always considered in project cost estimates; however, the usage in this context often refers to cost/schedule overruns and does not include potential liability costs.
External costs	Potential social or external costs that companies do not at the present bear, such as the costs of residual pollution.

Table 3: Cost categories[9]

A 1995 survey study funded by U.S. EPA[10] provides a useful classification of these largely software-based tools, highlighting the tasks to which each is suited:[11]

- *Cost-estimation tools* are used to predict or forecast, within a defined scope, the costs required to construct and equip a facility to manufacture goods or to furnish a service.

[9] Adapted from EPA 1996, *Incorporating Environmental Costs and Considerations into Decision-Making*, and EPA 1995, *An Introduction to Environmental Accounting as a Business Management Tool: Key Concepts and Terms,* 742-R-95-001.

[10] *Incorporating Environmental Costs and Considerations into Decision-Making: Review of Available Tools and Software.* EPA742-R-95-006, February 1996. Category descriptions are paraphrased and adapted.

[11] Examples of tools from the last three categories — those that are most related to the environmental aspects of decision support for EPR — are contained in Appendix B.

- *Scheduling and cost control/analysis tools* Scheduling tools assign estimated duration and start and finish times to each activity in a project, both to estimate time required for completion and to formulate a plan for completing the project within a scheduled time. Cost control tools track and calculate cost and schedule performance against target. Scheduling and cost control are often integrated.
- *Risk and contingency analysis tools* facilitate the assessment of risks and uncertainties for incorporation into project cost estimates and financial analysis.
- *Environmental management and regulatory compliance tools* are designed to facilitate environmental management of facilities for EHS regulatory compliance and/or corporate environmental management. They track chemical use and waste, facilitate or generate required environmental reporting, and produce other metrics relevant to assessing compliance or continuous improvement.
- *Remediation project-related tools* facilitate cost estimation, scheduling and cost tracking, feasibility study/planning and risk analysis, and regulatory compliance for remediation projects. As such, they integrate a number of the functions found in other tool categories, but are highly specialized toward remediation projects.
- *Financial analysis tools* provide information, methods, and computational support for the comparison of projects or project outcomes in financial terms.
- *Environmental life-cycle costing and impact analysis (LCC/LCA) tools* are designed to identify, estimate, and/or analyze life-cycle environmental costs and impacts for specific projects or products, product lines, or facilities. Life cycle *costing* covers conventional business costs and adds to these costs the monetized values of environmental impacts; impact *analysis* inventories life-cycle environmental impacts, but may not monetize them.
- *Waste reduction tools* are designed to provide general or project/facility-specific guidance on methods to effectively manage wastes and environmental costs. These tools generally are confined to the manufacturing facility and reducing its waste stream; they do not easily account for the effects, for example, of recycling or reuse of materials/products on the manufacturing waste stream.

This list can be expanded to include:

- *Design for environment (DfE) tools* facilitate the evaluation of alternative product designs for environmental performance. The distinction between LCC/LCA and DfE is (1) the latter emphasizes comparative assessment; (2) costs considered with DfE tools are typically only conventional manufacturing costs, and (3) environmental impacts are unlikely to be monetized with DfE tools.

As discussed, making the business case for EPR requires that the firm have an advanced understanding of the potentially hidden and contingent environmental costs of their current operations. This understanding provides data for and informs the analysis required to make the EPR business case. *Integrated or activity-based accounting systems*, while not product development tools *per se*, are crucial determinants of firms' capability to undertake this analysis.

This classification scheme reveals a set of tasks which business generally considers as functionally discrete. Decision support for EPR — that is, facilitating the analysis necessary to assess the EPR business case — would integrate a number of these tasks:

- From DfE, the ability to compare alternative product offerings, but with a focus on the environmental and cost/financial performance of alternative life cycle management approaches.

- From LCA, the ability to assess environmental performance over the product lifetime. From LCC and Total Cost Assessment, an effort to identify real and contingent costs to the firm often overlooked by standard business methods. (Unlike LCC, monetization of external costs is likely not necessary, as these contribute nothing to the business case),

- From the suite of traditional business cost and financial analysis tools, the ability to clearly articulate bottom line impacts of a prospective product offering.

In short, EPR decision support tools should facilitate comparison of the financial/business and environmental performance of alternative product offerings. Alternative product offerings here mean both similar products differentiated by their means of production, and by alternative means of managing the product throughout its lifecycle. In assessing prospective business performance, the tool would capture hidden and contingent, as well as conventional costs.

Comparison of these requirements to the coverage provided by existing tools gives, at first glance, an optimistic picture. The figure below is abstracted from the 1995 survey study; it provides a rough indication of the extent to which tools in each category tend to cover (1) the different phases of the life cycle and (2) different categories of costs. (Though the study is several years old, these remain sound characterizations of the coverage provided by the different tools.) As can be seen, for example, cost estimation and financial analysis tools have good coverage over all but upstream elements of the life cycle; LCA tools provide broad coverage — by design — across many stages of the life cycle and cost types.

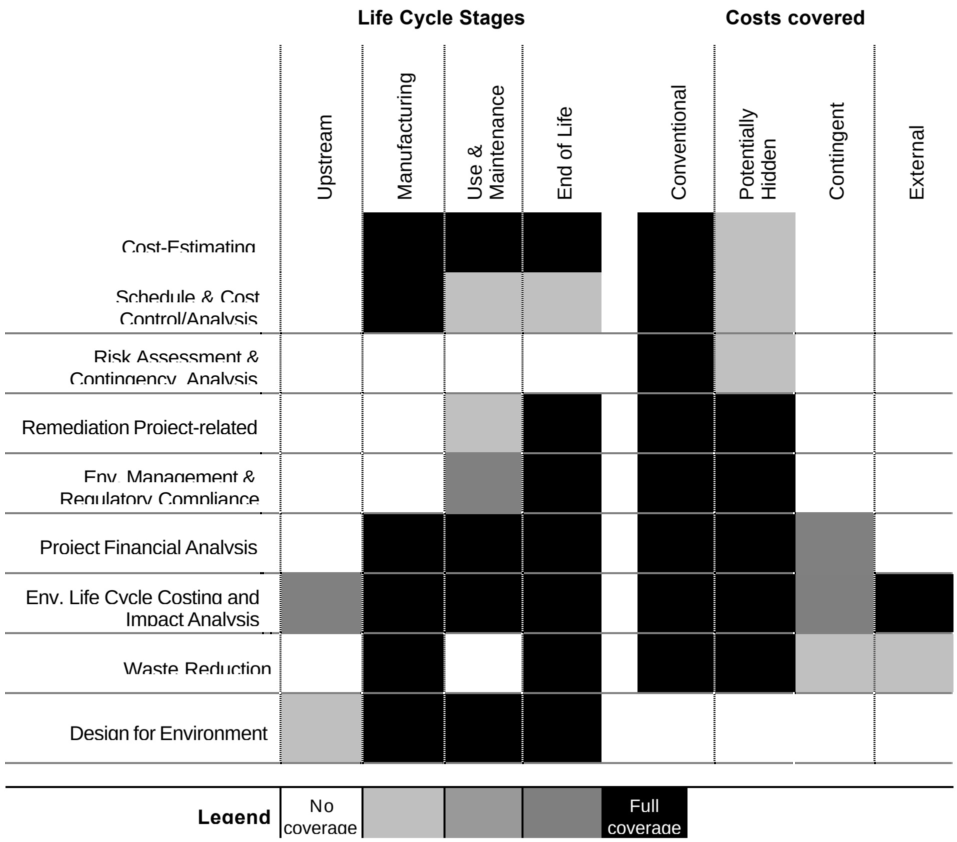

Figure 4: Life Cycle and Cost Coverage of Environmental Tools[12]

This simple picture, however, obscures a number of shortcomings in the current toolset relative to EPR requirements. These shortcomings center around the integration of elements necessary to make the EPR business case:

- While many of these tools encompass most life cycle stages, their coverage of costs, especially nonconventional costs, is less than complete. Thus, costs/benefits pertinent to an EPR analysis (e.g., revenues of "green" products, environmental costs) are apt to be excluded by these tools.
- "End of life" analysis for most of these tools encompasses waste management options (i.e., recycling, landfilling, and incineration). Thus, these tools are incapable of extending their analyses to include EPR options like take-back and remanufacturing.

[12] The survey from which the figure is derived employs cost classifications based upon EPA's cost definitions.

- Contingent cost and risk analysis rarely involves environmental contingencies and risk.

- Although a number of design for environment tools do exist, these typically address the environmental implications of alternative product designs only. Very few tools incorporate frameworks or structures that facilitate analysis of a number of EPR actions such as servicizing products or end-of-life management.

These shortcomings help to explain the *clear consensus* arising from our case study interviews — *that current tools are inadequate to the challenge posed by EPR, and that superior tools could significantly enable EPR by making it easier to demonstrate a business case.*

While it is beyond the scope of the current work to comprehensively assess trends in environmental tool evolution and offerings, vendor offerings and in-house products are of course evolving. While no tool precisely satisfies the characteristics for an EPR decision-support tool discussed here, evidence of greater integration and facilitation of comparative decision-making includes:

- A collaborative total cost accounting development effort by a set of large chemical user/manufacturer firms under the aegis of AIChE (American Institute of Chemical Engineers) is underway. The tool is intended to inform product decision-making by offering a total assessment of environmental, health and safety costs, including "future and contingent, internal and external liability costs associated with products and processes." Relative to EPR requirements, this will be a total cost accounting tool which facilitates alternative product comparisons, but not one specifically focused on comparison of life cycle management options (e.g., comparing recycling to landfilling or reuse versus recycling comparisons). The tool does incorporate some externalities, both environmental and social.[13]

- KM Limited offers a software package which it advertises as combining "Activity-Based Costing" and "Life Cycle Assessment," which facilitates comparisons of alternative product offerings. Again, the tool is not specifically geared to analysis of alternative life cycle management options.

[13] Project description: "Total Cost Accounting," American Institute of Chemical Engineers — Center for Waste Reduction Technologies" (website: http://www.aiche.org/docs/cwrt/projects).

4. TOOL DESIGN RECOMMENDATIONS

EPR decision-making within the firm is comprised of a three pronged analysis as shown in Figure 5.

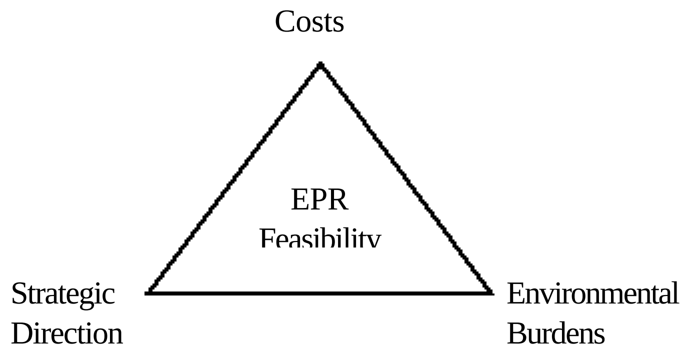

Figure 5. EPR Feasibility Assessment

First, the firm must decide whether EPR activities comport with the firm's strategic direction. Thus, the firm must consider whether these activities will enable it to build customer support and loyalty, maintain or expand market presence, and maintain or expand its competitive position in the marketplace. Tools such as market analysis enable firms to conduct this assessment.

Second, the environmental burdens of EPR activities must be assessed and compared to current environmental burdens. Life cycle assessment and DfE tools described earlier enable this analysis.

Lastly, in the voluntary EPR environment, unless EPR activities are demonstrably cost-effective, such efforts will flounder. It is this component, costs, that tools for assessing environmental burdens (such as LCA) stop short of including. Our discussions with nine firms implementing EPR activities, combined with a review of existing decision support tools, indicate the need for a tool that facilitates collection and analysis of cost information necessary for EPR decision making.

Our review of available tools reveals that while cost estimating tools are available, the analysis capabilities of these tools stops short of the level necessary for EPR. As noted during our interview with Xerox Corporation, a narrow cost analysis that (1) excludes less tangibles and (2) fails to consider costs and savings over the full life cycle of the product and (3) fails to aggregate costs and savings across all business functions involved in EPR may result in screening out financially sound initiatives. These three features describe the core capabilities and purposes for future generations of tools that may be developed to assist EPR decision-making.

General Parameters

All interviewed firms agreed that EPR decision making requires input across many divisions and staff functions within the firm. EPR tools could potentially be employed by design teams during feasibility or product concept studies which may involve a number of staff and divisions, by groups engaged in internal support for EPR activities, and by a strategic environmental unit attempting to "sell" EPR to the larger organization. Thus, the tool should not necessarily be viewed as an "environmental" tool or "accounting" tool, but rather interface with a multitude of staff functions.

Second, firms agreed that it would be useful to have a tool that covered all product life cycle stages, as well as conventional and less tangible costs such as revenue impacts of EPR legislation and market preferences for "green" products in Europe, changes in market share, customer loyalty, etc. Such capabilities are lacking in many of the tools these firms are currently using.

There was no widespread agreement as to whether an EPR tool should integrate both environmental and cost data, or only cost data. Some firms felt that their needs would best be met by an integrated tool. However, as many firms are already using multiple tools for assessing environmental impacts and cost impacts, a nonintegrated tool would be suitable for their current decision making approach.

Structure

An EPR tool should be adaptive to the different decision making climates between firms, as well as adaptive to differences between divisions in the same firm. For example, as noted by 3M, product diversity leads to very differing decision frameworks across the company. Thus, the tool's structure should not be prescriptive (e.g., requiring data for all life cycle stages). This suggests a modular structure for a tool, wherein the user could decide which module(s) to use based upon the requirements of the analysis being conducted. As noted by Ford, a discretely segmented tool could be used by both suppliers and vehicle manufacturers.

The tool should facilitate comparative decision making (e.g., comparing costs associated with two different design options). Thus, structurally, the tool should enable the user to assess and aggregate costs across the product's life cycle, but also allow for comparison of these costs between alternative means of delivering the same value or service. (e.g., different end-of-life management options, extended durability, and dematerialized functions such as replacing phone answering machines with phone answering services).

Several of the firms suggested that the tool should help the user "ask the right questions." Structurally, a checklist that provides examples of questions to pose throughout the EPR decision-making process and provide examples of where within, or external to, the organization such information may be housed, would help advance EPR at this level. Thus, an EPR tool could be modular both in breadth (i.e., across the product life cycle) and depth (e.g., a high level checklist, followed by a more data-intensive analysis tool.)

Should an EPR tool be paper or computer based? A checklist approach could readily be embodied in either; a computer based tool would better suit development of a quantitative tool.

The greatest challenge to developing a decision support tool is recognizing that user needs cannot be fulfilled via a "one size fits all" tool. Thus, the tool should provide flexibility both in its design and application, while avoiding an overly simplistic design that does not further the EPR decision making process.

APPENDIX A: CASE STUDIES

EPR Case Study: 3M

Company Overview

Founded in 1906, 3M (Minnesota Mining and Manufacturing Company) is a diversified Fortune 500 company with more than two dozen core technologies which range from coating substances, adhesives, abrasives, to fluorochemistry and micro-replication. 3M manufactures or sells more than 50,000 products, serving markets ranging from health care to chemicals to computers and electronics. 3M employs 75,000 worldwide, with manufacturing operations in 41 countries. Net 1997 revenue was $1.63 billion on worldwide sales of $15 billion.

EPR Activities

3M's corporate environmental policy includes commitments to pollution prevention and developing products which have a minimum effect on the environment. 3M is generally credited with pioneering the idea of bottom-line rewards to pollution prevention, exemplified by the corporation's "Pollution Prevention Pays" program established in 1975. 3M has formally identified "Developing environmentally improved products and processes using Life Cycle Management techniques" as one of the three main elements of its Environmental Management System. 3M characterizes this as extension of existing approaches to product responsibility to more fully consider life cycle issues.

- Traditional manufacturing processes for adhesive and abrasives employ solvents to deposit material (e.g., adhesive) onto backing (e.g., paper tape). 3M notes it has devoted significant attention to reducing solvent use in this area; the company anticipated that all of its abrasives manufacturing facilities worldwide would use water-based resins by the end of 1997.

- 3M describes extensive alterations to the Thinsulate™ manufacturing process to incorporate 50% recycled polyester fibers. 3M developed the first CFC-free metered dose inhaler for the treatment of asthma.

- 3M describes a program at its Greenville site to collect polyester transparency film for recycling into new transparency film and other products (claimed as the first U.S. program to provide end-user transparency recycling).

- 3M describes efforts on providing support to end-users to reduce use-associated environmental impacts, including development in cooperation with the American Furniture

Manufacturers Association of guidelines on the use of coatings and other materials, and an effort to providing European customers with recycling information for waste.

Institutional and market context shaping EPR activities

EPR & product development

Product development within business units (divisions) is guided by a new product introduction process. The process addresses environmental, health and safety concerns via Product Responsibility Reviews at each development stage (e.g., concept, pilots and test marketing, market entry). (The process also targets more traditional aspects of the product development process — e.g., assuring manufacturability, provision for quality control, and viability of marketing plans.) Product Responsibility Reviews follow 3M's Product Responsibility Guidelines for the Introduction of New or Modified Products, which formally incorporate Life Cycle Management (LCM) principles. The Guidelines are intended to serve as guides, not prescriptive policy; applicability of their different elements will depend on the nature of the product being developed.

Product Responsibility Liaisons within each division have primary responsibility for the product responsibility review process. Liaisons are also the point-of-contact for bringing specialized expertise within 3M to bear on aspects of product responsibility during the review and development process. This networking or inside consultancy process could tap, for example, internal legal, environmental health, and manufacturing expertise.

Formal inclusion of LCM is a recent development. 3M's LCM model addresses environmental impact of its products at all stages of its life, which includes the material acquisition, R & D operations, manufacturing, customer use, and disposal stages of each product. The types of impacts considered at each life cycle stage include environment, energy and resources, health, and safety. Again, this is a high-level model; particulars of its application are left to the division level.

From the corporate perspective, next steps focus on education within the organization and tool provision, including software-based tutorials and assessment tools.

EPR drivers

- **Environmental leadership as market advantage**. Increasing numbers of customers differentiate between products based on their environmental characteristics.

- **Proactive LCM saves time, reduces liability.** Systematic approaches to LCM minimize EHS-related oversights (and therefore liability) in the introduction of new products and support rapid product development by considering environmental issues prior to product scale-up, field test, or market introduction.

- **Corporate commitment.** 3M states that LCM is consistent with responsible corporate citizenship and a corporate tradition of responsible environmental actorship.

EPR barriers and challenges

- **Information assembly costs.** LCM demands some level of life cycle assessment (LCA), which can be very data-intensive. Basic LCA information (quite apart from value-dependent judgments, such as the relative environmental merits of steel vs. aluminum) is not available centrally and must often be reassembled from project to project.

- **Focus on time to market.** Though 3M believes that environmental values are ingrained in its corporate culture, time pressures to move a product to market are real and can present a temptation at the division level to abbreviate elements of the product introduction process, including responsibility reviews.

- **Diversity of product types, uses and use environments.** Because of 3M's diverse range of products, no one EPR/LCM approach is applicable. For example, take-back may be clearly indicated for certain solvents, but take-back for Post-it® Notes is impractical and efforts must focus on achieving product compatibility with paper recycling technologies. Further, it is difficult to envision all product uses and use environments, particularly outside the U.S., during product development.

- **Diversity of regulatory environments**. LCM/EPR is essentially a beyond-compliance approach to environment, with certain exceptions in European markets. The diversity of regulatory environments in which 3M manufactures and sells and the lack of regulatory harmonization increases regulatory compliance burden, and reduces resources available for beyond-compliance activities.

- **Segregation of responsibility**. Historically, responsibility for product EHS issues has been a assigned to designated individuals and offices. Integrating responsibility across functions (e.g., manufacturing, marketing, etc.) is necessary to operationalize an LCM-based product development approach, but represents a cultural change to the organization.

- **Partnering with upstream & downstream functions**. Manufacturer "ownership" of all environmental issues associated with a product over its entire life cycle is impracticable for all but a few products. The high degree of manufacturer control over distribution, use, and disposal implied by the ownership model cannot be achieved for most products. Therefore, partnering with suppliers, but also with distributors and users is critical. Forming such partnerships is a difficult and largely untested area, complicated by the fact that partnerships up and down the life cycle chain must allow 3M to maintain its proprietary interests.

EPR Information gathering

As described above, EPR/LCM at 3M relies upon an internal network providing consultancy and specialized expertise as needed to product development efforts. The point-of-contact is the product responsibility liaison; references are offered to 16 staff groups (toxicology, energy, engineering, general council, etc). The types of information obtained for EPR decision support might include regulatory, toxicity, industrial hygiene, environmental effects, testing, and historic use information or simulated scenarios for adjusting designs. Amongst this information, cost is factored in.

As above, diversity of data sources is problematic, and there is no single repository of product responsibility data, nor a belief that such a large database could be usefully built or structured. Likewise, no single information-gathering protocol is practical, due both to the diversity of products which 3M manufactures and the stifling effect which a rigid and inapplicable protocol might have on innovation. Product responsibility assessment requires that significant expert value judgements be made within the very high-level LCM model.

Perspectives on an EPR decision-support tool

Because of its product diversity, only a very high-level tool (checklist, software-based, or other) would work across 3M. From the corporate perspective, the goal should be to provide EPR/LCM tools which facilitate the right questions being asked across the product life-cycle, but are not prescriptive or limiting. Towards this end, an LCM program is being adopted whose implementation guide has examples of questions to ask throughout the EPR decision-making process. As part of this program, 3M is putting together a Lotus Notes® based program currently in beta-testing. Overall, 3M does not have prescribed tools except in highly specific and detail-oriented cases, such as toxicity testing.

Some consideration is being given to putting basic LCA information for basic materials and manufacturing technologies with wide application in 3M into a corporate database, or referencing external databases for use as appropriate. This information could include energy content of various materials or a material's contribution to global warming, for example.

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EPR Case Study: DuPont

Company Overview

DuPont (E.I. du Pont de Nemours and Company), a major multinational chemical company, is a diversified producer of chemicals, petroleum products, high-performance materials, pharmaceuticals, and biotechnology products. Headquartered in Wilmington, DE, the company operates more than 150 manufacturing facilities in 40 countries. DuPont had a net 1997 income of $2.4 billion on revenues of $45 billion.

EPR Activities

DuPont has a stated commitment to continuous improvement in environment, health and safety, and to pollution prevention. Although a formal commitment to EPR is not part of DuPont's environmental policy, the company highlights its participation in a number of EPR activities covering significant elements of the product life cycle:

- EPR incorporates the concept of product stewardship. As a member of the CMA (Chemical Manufacturers Association), DuPont participates in the Responsible Care program, a major focus of which is product stewardship. For DuPont, this stewardship activity is primarily focused on information provision — clear communication of product characteristics and risks, and safe handling procedures. Stewardship activities have begun to extend to involvement at the customer location — e.g., audits. Every strategic business unit has a stewardship coordinator and every product manager is the steward for his or her product.

Examples of EPR activities involving particular products include:

- nylon recycling in carpets; DuPont is the world's leading nylon recycler and offers a carpet service integrating installation, maintenance, and recycling;
- development of polyester (PET) film regeneration technology (Petretec™). The technology employs a chemical process to reduce PET to its original feedstocks, allowing a much higher level of contamination in reclaimed film than that tolerated by mechanical methods.
- Packaging take-back, reuse, recycling is supported by a number of DuPont businesses (including outside of Europe where it is mandated), including herbicide container (plastic jug) recycling; and

- plastics recycling in envelopes; the Tyvek business uses 25% post consumer HDPE in its production of Tyvek envelopes and offers an infrastructure to recycle the used envelopes into plastic wood decks.

Institutional and market context shaping EPR activities

EPR & the organization of product development

Formal commitment to EPR is not part of the product development process. However, every DuPont product is subject to a formal product review which is a protocol for evaluating the product's manufacturability, liability implications, energy and environmental impacts, and other characteristics of potential concern. The EHS portion of this evaluation produces a classification corresponding to the inherent hazards of the product; the classification determines the frequency of subsequent evaluations. Questions central to EPR are increasingly becoming part of these evaluations, such as

- should take-back be considered?
- has life extension been considered?
- can recycled materials be used?
- is it recyclable?
- is the proper customer information provided for safe handling, use and disposal ?
- are use site audits or protective equipment needed?

In cases where there is grounds to believe that a reasonable business case can be made for EPR activities beyond information provision, LCA-type assessments have been performed (see information-gathering, below) to evaluate the strength of the business case.

EPR drivers

- **Regulations and potential regulations.** Regulation can require EPR activities; the prospect of regulation can: (1) induce firms to engage in EPR activity as an anticipatory measure, or (2) induce industry groups to organize for EPR activity to head off regulation. For example, the European take-back regulations mean that take-back is a condition of doing business, not a cost which must be justified. In the U.S., the expectation of state or federal regulation and the desire to do business in Europe is pushing U.S.-based operations to become more familiar with EPR issues.

- **Customer values/demand.** Some customers will pay a premium for environmentally superior products, valuing reduced packaging, increased recycled materials content, lower energy usage, etc. If demand for green products in a particular market is sufficiently high, EPR activities are incentivized. In certain markets, large customers wield sufficient market power to impose recycled content and other EPR practices on their suppliers. Ford, for example, requires recycled content in certain polymers; suppliers had little choice but to comply.

- **Competitive pressures.** Where an EPR activity demonstrates economic success and enjoys high visibility, competitors can be forced to imitate a lead actor. Both Allied-Signal and BASF are developing nylon carpet recycling capacity in wake of DuPont's success, for example.

- **Cost/quality** (via environmental factors). There is some belief that the activities necessary for improving the environmental characteristics of production processes (process optimization, waste and energy reduction, reduced reject rates) can simultaneously drive continuous quality improvement and cost reduction.

- **Material constraint**. A shortage of a raw material or a significant environmental issue surrounding its use (e.g., greenhouse gas emissions) would drive producers to incorporate environmental considerations into their decision making. (Not currently a reality).

- **Sustainabilit***y*. A limited number of progressive companies will make additional, beyond-compliance and narrow cost-benefit environmental efforts out of a commitment to sustainability/social responsibility principles.

EPR Barriers and Challenges

- The examples of EPR activities and initiatives cited above, while significant by themselves, represent a minute portion of DuPont's products. It has been difficult to find situations in which engaging in EPR activities beyond information provision — such as take-back, recycling, etc — makes a convincing business case. Regulation is thus the strongest potential driver to EPR. Economic impediments to EPR include:

- **Environmental costs not internalized**. Low raw materials, energy and disposal costs increase the relative price of recycled-content materials and bias the market towards a preference for virgin materials. This is particularly true in the U.S. (as compared to Europe) where disposal and energy costs are relatively low.

- **Inflexible, large-scale plant and sunk costs**. Production facilities (especially for bulk chemicals) are capital intensive, integrated, and highly specialized — characteristics which raise the threshold level of economic return necessary to justify changes in facilities to accommodate recycling/reclamation. The economics of scale which facilities embody also require large throughput and volume in any recycling or take-back effort to run at economically viable utilization rates.

- **Customer perception.** While some customers value superior environmental characteristics in a product, recycled content in particular is perceived negatively by others due to concerns over quality and aesthetics.

- **Dispersive uses/transformed product.** While some DuPont products are minimally altered for final consumption uses (e.g., nylon for carpet), most others are (1) chemically transformed (e.g., chemical feedstocks), (2) used in intrinsically dispersive applications (e.g., agricultural chemicals), or (3) form a small part of a final assembled product (e.g., o-rings and gaskets). Recycling or take-back is all but impossible for the first two categories, and highly impractical in the last. These factors limit the variety of and opportunity for "usual" EPR activities such as recycling and take-back which a chemical manufacturer can pursue.

EPR information gathering

A business assessment of a product or initiative with EPR characteristics (recycled content, take-back, etc) is one which DuPont feels is reasonably straightforward, as well-developed standard analysis and assessment tools can be brought to bear. Environmental inventory assessments are less straightforward. Dupont's assumption is that an increase in recycling and reuse results in environmental improvement. This is quantified when necessary in support of a business case using life cycle tools or by referring to past studies.

DuPont's analyses of EPR projects would include a comprehensive coverage of production, retrieval, and recycling costs, such as:

- materials separation (mechanical or chemical)
- reprocessing
- trucking
- storage
- labor
- reject rate
- other infrastructure requirement
- avoided costs, such as land-filling

Perspectives on an EPR Tool

A decision-support tool that helps firms ask the right questions and calculate the environmental and economic impact of EPR programs would be useful, but many companies may feel that their knowledge and ability to perform this type of analysis is superior to anything that would come from an external source. Marketing the tool would thus be a significant challenge.

In any case, the tool should provide an example, including typical cost values (e.g., for recycling, landfilling, collection infrastructure, sorting, material recovery facilities, etc.). Other issues, such as customer/market preferences, possible mitigation of regulatory burden, and other intangibles should also be included, since they are important and difficult to assess aspects of the evaluation.

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EPR Case Study: Ford/Visteon

Company Overview

Ford Motor Company manufactures, assembles, sells, rents, leases and finances cars, trucks and related parts and accessories. The world's second largest automaker, Ford operates more than 180 plants worldwide, employing 360,000 workers. Net 1997 income was $6.9 billion on revenues of $153 billion. Included in these figures are wholly owned businesses, including the subject of this case study, Visteon. Visteon Automotive Systems is Ford's components operation, organized as a separate group in 1997. Visteon operates 74 plants in 19 countries, with 78,000 employees.

EPR Activities (Components operations)

In its annual reports, Ford has committed to environmental leadership in the automotive industry. With respect to component operations, formal commitment to EPR is not a part of the corporation's environmental policy *per se* — however, Ford highlights its engagement in significant EPR activities in the component area. These focus on vehicle recyclability and incorporation of recycled materials:

- In 1993, Ford Motor Company implemented worldwide Recycling Design Guidelines for its suppliers and engineers. The company claims this as a first in the industry. The guidelines cover "development standards for maximum recoverability of a vehicle and design processes for engineers and suppliers," and establish progressive recycled content targets. The company has engaged in an ongoing internal process to identify strategic initiatives necessary to meet recycling/recovery goals. Examples of recycled components applications include:

    - Recycled nylon resin from carpeting is used in fan modules and air cleaner assemblies

    - Recycled tire rubber is used in air deflectors, baffles, and splash shields

    - Recycled HDPE resin from soda bottles is used in luggage racks, grill reinforcement and door padding.

    - Recycled Xenoy resin (a blend of polyester and polycarbonate resins) from recovered bumpers is employed in new bumpers.

- Ford maintains its Experimental Dismantling Center in Germany. The center dismantles vehicles to benchmark design practices and materials use against materials recovery capability. Ford notes that best practice information established by the center will ultimately be disseminated to a network of Ford-licensed dismantlers to promote maximum material recovery at end of vehicle life.

Institutional and market context shaping EPR activities

EPR and product development

Standards for component recycled content and vehicle recyclability have been promulgated and formally imposed as a top-down requirement on the design process. In part due to this standards-based approach, there is no centralized cost/benefit assessment process for EPR activities and decisions. Responsibility for assuring adherence to these standards primarily falls on vehicle line directors — in the specific case of Visteon, line directors dealing with plastic components. (Design/performance requirements are encapsulated in an "18-panel chart," of which environmental requirements/metrics occupy one panel.)

The performance of line directors is judged on their ability to meet design and performance standards, including recycled content/recyclability. Line directors in turn impose this performance requirement on engineers, who are required to take company training in vehicle recyclability. The material approval process is quite rigid with regard to recyclability/recycled content.

To achieve this mandate, interactions with materials suppliers take several forms:

- **Imposed requirements**. To a limited extent, Ford has sufficient market power as a large volume purchaser to create demand and stimulate supplier capability to deliver recovered materials of a particular specification. This is particularly true with sufficient contract lead time. Eventually, Ford would prefer to require its full service suppliers to recover their end-of-life components.

- **Developing supplier capacity and infrastructure**. Infrastructure for materials recovery is not sufficient in the U.S. to deliver quantity and quality of recovered inputs demanded by progressive implementation of recycled content requirements. Visteon has engaged in pilot projects with specific materials suppliers to build this capacity. The hope is to leverage success and visibility of these pilot efforts into a more competitive sector.

- **Supporting commercialization of promising technologies**. Visteon has supported commercialization of relevant recovery/recycling technologies, such as paint removal and resin identification systems. Returns to such investment take the form of cost savings, being split between the supplier and Visteon/Ford. Criteria used to screen processes for R&D/commercialization support are technical and economic — that is, does the resulting product show promise of meeting performance requirements, and does the process show promise of delivering this product at acceptable cost? New suppliers or those using trial technology go through a probation period, in which ability to meet quality, cost and schedule are assessed.

EPR drivers

- **Competitive advantage**. Visteon, while a Ford business, competes in the components market for business from other automakers. Commitments in the auto industry to increase recycled content and recyclability (mandated in Europe) confers an advantage on firms with demonstrated ability to manufacture quality components with recycled content and to design for recyclability.

- **Regulation/ Head off regulation**. In Europe, and particularly Germany, regulation and compacts mandating recycling and take-back are driving the industry. In the U.S., proactive practices on recycling and design for recyclability are seen as a means of heading off the need for regulation.

- **Corporate commitment**. Ford perceives some market value in the manufacture of "greener" vehicles and has for that and other reasons — including a stated commitment to environmental leadership —committed to EPR activities in the components area.

EPR barriers and challenges:

- **Diversity of materials, labeling.** The large number of plastics and resins in the average U.S. vehicle and the fact that most components in the extant vehicle fleet are unlabeled poses difficulties for materials recovery efforts. "Commonization of materials" and pervasive labeling are is a major goal of Ford's Worldwide Recycling Design Guidelines. (The proportion of labeled components will rise as cars currently being produced reach end-of-life.)

- **Inadequate infrastructure and supplier capabilities.** As noted above, infrastructure for materials recovery is not sufficient in the U.S. to deliver quantity and quality of recovered inputs demanded by progressive implementation of recycled content requirements. Likewise, supplier technical capabilities (and to some extent the technologies themselves) are insufficient and the producer market for recovered materials is in general not competitive.

- **Higher costs of recycled materials**. When performed on a small scale and in the context of an uncompetitive producer market, producer opportunism and the costs of disassembly, sorting, cleaning, etc. tend to make recovered materials more expensive than virgin. This is a "chicken and egg" problem — high demand would permit the exploitation of economies of scale in recovery operations and stimulate a more competitive market — but the development of high demand is contingent on economic attractiveness of the current product.

  (A perverse consequence of materials commonization is that it drives adoption of "commodity" rather than specialty plastics. Virgin material costs of commodity plastics are extremely low, making their recovery less economically attractive.)

- **Competitive relations between automakers**. Recycling and recovery could benefit from coordination and cooperation between automakers — in demand creation, in materials standardization, in shared knowledge of management systems and initiatives. Competitive attitudes in this area, including competition for a limited supply of recovered product and reluctance to discuss management techniques may retard progress in the area as a whole.

EPR information gathering

As recoverability/recyclability — or outright vehicle take-back — requirements increase, meaningful cost/benefit assessment to guide recycling and recovery choices involves comparing costs from purchasing through disassembly and recovery. Manufacturing and materials costs must be traded off against disassembly and recovery costs, for example. Where a full service supplier is obligated to recover end-of-life components (a model Ford has identified as desirable), Ford Automotive's assessment might consist simply of purchase price, assuming the part meets recycled content/recyclability requirements. The burden of life cycle costs assessment then falls on the supplier, whether Visteon or a third party.

Currently, no centralized function at Ford (Ford Automotive or Visteon) carries out this assessment, and data are not integrated. Lack of data integration has been recognized as problem; an accurate materials tracking database was identified as an initiative area to fulfill worldwide recycling guidelines

Perspectives on EPR Tool

A tool would have to be very flexible and possibly discretely segmented, as it could potentially be used both by suppliers and vehicle manufacturers, and by different functions within each (e.g., a technology portion of the tool would be used by engineers, while the implementation and cost portions would be used by others in the product development process). The full life cycle of costs would be incorporated, as well as the impact of alternative approaches to logistics and infrastructure. (E.g. buying pre-blended recycled content feedstock, vs. blending recycled feedstock into virgin material at the component-making plant.) Ford does monetize the environmental impacts and would also appreciate a similar feature in the decision support tools of the future.

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EPR Case Study: IBM

Company Overview

IBM (International Business Machines Corporation) develops and sells advanced information processing products which include computers, microelectronic technology, data storage devices, software, networking and related services. IBM employs nearly 270,000 and operates 33 manufacturing, hardware development and research sites in 14 countries. 1997 net earnings were $6.09 billion on revenue of $78.5 billion.

EPR Activities

IBM's corporate environmental policy pledges the company to several EPR-related goals: conserving natural resources through material reuse and recycling, including employing recycled material in products; and developing environmentally sound and energy efficient products. EPR activities as defined in this study are enacted in the company through IBM's Environmentally Conscious Products (ECP) program, established in 1992.

The ECP program establishes five design objectives for IBM products, which have been incorporated into the company's product development process. These objectives are incorporated in a corporate standard for environmentally conscious design to which all new products must adhere. The ECP program design objectives are to:

- Develop products with consideration for their upgradability to extend product life.
- Develop products with consideration for their reuse and recyclability at the end of product life.
- Develop products that can safely be disposed of at the end of product life.
- Develop and manufacture products that use recycled materials where they are technically and economically justifiable.
- Develop products that will provide improvements in energy efficiency and/or reduced consumption of energy.

Examples of initiatives and activities under the ECP program include:

- **Recycled content and increased material recovery.** IBM seeks to increase both recycled content and product recyclability through parts labeling and changes in assembly methods A 30 percent worldwide decrease in landfilling of product-related scrap is reported since 1995 as well as significant increases in the amount of recycled plastic incorporated into products.

- **Product power management.** All product lines strive for continuous improvement in product energy efficiency. IBM's commitment to the EPA Energy Star program and the company's technology innovations in microelectronics, disk drives and monitors earned IBM the EPA's 1998 Energy Star Computer Partner of the Year award.

- **Supplies Return Program** to remanufacture, reuse or recycle printer consumables.

- **Product end-of-life management (PELM) activities.** Product take-back (PTB) programs began in Europe in 1989, and were extended to U.S. commercial customers in 1997 with the announcement of the IBM Credit Corporation (ICC) PELM Service Offering. Currently, IBM has thirteen PTB programs operating world wide to take back end-of-life (EOL) computer equipment from external customers. Most of these programs are supported in the local country by an IBM Materials Recovery/Recycling Center (MRC) for the collection and processing of EOL equipment. In addition to these PTB programs, IBM has a network of approximately thirty MRCs world wide for the processing and/or collection of IBM owned EOL equipment. This equipment is generated from end of lease agreements, field returns, local manufacturing plant obsolete and surplus, and replacement of IBM personnel equipment. In 1997, this network of MRCs processed over 62,000 metric tons of EOL product scrap recycling over 94%. Some smaller MRC operations are now collecting product scrap and shipping it to larger "full service" MRCs for greater recycling efficiencies and consolidation. These "full service" MRCs also provide refurbishment and reutilization of selected machines and parts. This activity extends product and part life through the secondary marketing of used equipment and the reuse of qualified/certified parts for field repairs. Another important part of these operations is the removal of environmentally sensitive parts prior to either full disassembly or total scrapping of the EOL product. The removal of parts such as batteries and capacitors are required for safe processing of the equipment and to ensure environmental recycling or disposal of these parts.

Institutional and market context shaping EPR activities

EPR and Product Development

The ECP program provides design-for-environment (DfE) guidelines which are integrated into IBM's Integrated Product Development Process. Product development occurs within product divisions;

each IBM product division has an ECP "strategy owner," a high level manager responsible for overseeing the division's overall ECP strategy and explaining the strategy to the division's product managers. The strategy owner is also charged with setting ECP goals and performance metrics.

ECP program objectives are supported by IBM's Engineering Center for Environmentally Conscious Products (ECECP). ECECP houses the principal technical support staff who provide guidance to product divisions so that ECP goals are embedded in design and manufacturing decisions. ECECP is charged with translating ECP goals into concrete materials and process guidance to all business operations. For example, ECECP developed an ECP attribute rating system, encompassing 15 criteria, for use by product divisions to assess progress towards meeting ECP program goals.

IBM's EPR activities largely focus on procurement, materials selection, and EOL decisions. The company's Procurement Council, which is charged with making procurement recommendations for IBM, considers environmental burdens and recyclability of materials in its material selection process, in consultation with ECECP staff.

EPR Drivers

Proactive environmental management of products for competitive advantage is the primary driver. Demonstrating environmental leadership/sustainability through effective designs and efficient recycling of end-of-life products is also an important driver.

EPR Barriers

Significant barriers in the market include the customers' unwillingness to share in disposal costs and pay more for "greener" products. Inherent value of end-of-life equipment does not always support EPR expense. Technical barriers include the lack of a mature infrastructure for collection/recycling of end-of-life computers, and regulatory impediments to recycling materials previously used in older products.

EPR information gathering

For routine cost and savings consideration for EPR, IBM evaluates material costs, disposal costs, and recycling costs. Disposal and recycling costs are measured and managed by the local MRCs with monitoring from the corporate environmental staff. These measurements are performed in determining total operational profit/cost, selected (high volume or value) product disassembly cost, and individual materials commodity streams generated from disassembly. Also, cost avoidance and savings associated with the recovering and reuse of parts are measured and reported to upper management demonstrating the additional value of these operations.

IBM has conducted extensive studies at the IBM Endicott, N.Y. MRC in determining disassembly time and difficulty for EOL products representative of various IBM development operations. This information has been shared with product design teams through workshops and internal communications (reports, symposium, ECP newsletters). The goal is to provide this information to product design teams who do not routinely consider EOL costs and improvement opportunities.

Perspectives on an EPR decision support tool

IBM co-developed the Ecobalance/Ecobilan EIME (Environmental Information and Management Explorer) software tool that, via a sizable database, looks at design for environment and life cycle assessment indicators for new product designs. Several of the design indicators relate to the potential recyclability and waste generation projections for proposed product constructions. No cost or commodity pricing data is included in the software. This tool is currently used by ECECP staff to support DfE guideline development.

IBM believes that EPR decision support tools would be valuable as a means to integrate elements of total cost accounting into product design processes. Cost data integration for EPR, however, will depend on the outcome of various product take-back and disposal scenarios in many jurisdictions around the globe. These scenarios and the environmental design objectives that undergird them will need to be translated into cost factors for the design community in which product decisions take place. A financial tracking tool might, for instance, calculate the net value of a product design based on its content of commodity materials, hazardous materials, location-specific restrictions/expense to landfill, expense to incinerate, cost to disassemble, salvageable parts, etc. to allow designers to minimize EPR costs of the product for a variety of relevant scenarios.

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EPR Case Study: Monsanto

Company overview

Monsanto was historically a large chemical manufacturer, with product lines in industrial chemicals, coatings, agricultural and consumer products, pharmaceuticals, and others. Over the past several years, however the company increasingly focused on agricultural, food and health applications of biotechnology. In September, 1997, Monsanto spun off the majority of its chemicals business as an independent company, Solutia, and redefined itself as a "life sciences" company focusing on the application of biotechnology to agriculture, food and health. Except for working relationships in the form of service agreements, material supply arrangements, and an Idaho joint venture, Monsanto and Solutia are unaffiliated.

The new Monsanto is divided into sectors: Agriculture (engineered seeds and crop protection chemicals); Nutrition and consumer products (lawn and garden, food ingredients, artificial sweeteners); Pharmaceuticals; Health and Wellness (health care services and products other than pharmaceuticals); and Sustainable Development (biodegradable plastics/polymers, pollution-control and water treatment systems). With more than 20,000 employees, Monsanto's 1997 net income was $294 million on revenues of $7.51 billion (figures adjusted for spin-off of Solutia).

EPR Activities

In 1995, Monsanto made a stated commitment to pursuing sustainable development as a business opportunity. and as a guiding operating principle throughout the product life cycle. This commitment to sustainable development subsumed previous commitments to leadership in product stewardship. With regard to crop protection products (herbicides), now part of Monsanto's Agriculture sector, product stewardship/EPR activities include:

- The reformulation of products for lower environmental impact in production and packaging
- Training of transportation personnel to ensure safer distribution of products
- A program to provide training for proper pesticide applications

Institutional and market context shaping EPR activities

EPR and product development

Monsanto describes as a priority work-in-progress the integration of sustainability criteria into product development, with attention both to the manufacturing and use portions of the life cycle. The company notes that such integration necessarily rests on insights derived from life cycle assessment (LCA). By December 1998, Monsanto expects to have "defined high-sustainability criteria for all Monsanto products and a plan developed to apply those criteria."[14]

As many of Monsanto's businesses are acquired, business culture varies across the company's business areas. This is mirrored in Monsanto's product design/development process and the nature/extent of EPR integration, which varies significantly across business areas. Within "white space innovation" (product development occurring outside historical product groups), EPR evaluation is performed between each stage of product development — including product incubation, definition, assessment, development, commercialization and post-commercialization. This is one of several tools available to businesses; its use is encouraged, but not mandated. In the product definition phase, concerns/topics assessed include process inputs (materials and energy), the nature of the product and its service, possible current and future legislative impacts, and applications of the precautionary principle relating to toxic dispersion, etc.

Given the diversity of products, markets, and development environments, the corporate staff has not seen its role as one of providing prescribed, uniform tools. Rather, the focus has been on (1) employee education — working towards a corporate culture in which life cycle and EPR questions are asked as a matter of course; and (2) providing a variety of tools to the line businesses, which may employ them in this evaluation process if they are found to be useful. (Ecobalance LCA software has been used in a number of cases.) However, in support of the recognized basic need for life cycle assessment and costing capability, Monsanto, is engaged in a collaborative effort with AICHE (American Institute of Chemical Engineers) Center for Waste Reduction Technologies and a set of nine large chemical process-based manufacturers (including SmithKline Beecham, another company is this set of case studies) to develop a comprehensive total cost accounting (TCA) tool.

The tool development has pooled cost data from participating firms to provide a more complete and benchmarked data set than one firm could generate internally. Costs considered include "future and contingent, internal and external liability costs associated with products and processes,"[15] including a limited set of environmental externalities. (Liabilities employ actuarial methods and the cost of insurance;

[14] *Monsanto 1997 Report on Sustainable Development*

[15] AICHE project description. Project Title "Total Cost Accounting"

externalities include, for example, future options prices for CO_2 emissions. The tool does not consider supplier-related impacts). The effort is expected to produce a software-based tool; currently, the tool is in paper and spreadsheet-form.

Monsanto intends to integrate this tool with life cycle inventories, eco-efficiency indicators[16] and its SAP accounting system (tracking both monetary and material flows), which would provide the company with a fully integrated, total cost assessment system.

EPR Drivers

- **Better business decisions for long run**. In an industry where potential liabilities arising from products are extremely large and regulatory certification is arduous, Monsanto's efforts to apply EPR or extended environmental criteria to product decision-making is driven in large part by a desire to avoid unforeseen liability and increase chances for certification and product acceptance.

- **Corporate commitment.** Monsanto has made a public commitment to the pursuit of sustainable development as a business area, but also as a set of guiding operating principles

EPR Barriers

- **Data availability.** The lack of verifiable and consistent database on environmental costs, both within Monsanto and as experienced by process industries as a whole, is a significant barrier to the practice of LCA upon which EPR-based decision-making must rest.

- **Immaturity of tools.** Tools for EPR-based decision making are not well-established, and implementing this type of decision-making concurrent with tool development is a challenge. (Monsanto has employed various versions of the collaborative TCA tool over the past several years.)

- **Focus on penalties and liabilities, not opportunities.** In general, EPR tools and EPR-based decision-making is perceived as a way to understand liabilities and penalties associated with product decisions. Insufficient attention has been paid to its potential to identify business opportunities. Its negative connotations are a barrier to wider adoption.

[16] Ecoefficiency indicators are being developed in another collaborative initiate with Canada's National Roundtable on Environment and Economy.

EPR information gathering

Monsanto has this year put in place a uniform and upgraded data collection system for environmental data and costs, replacing a diversity of heritage accounting systems. There is a concurrent effort to integrate this information into the company's integrated SAP accounting system. If successful, this will provide the company with a fully integrated total cost assessment system.

The total cost assessment tool in development includes approximately 250 cost (and opportunity[17]) items, divided into five types.

- Direct costs include material, capital, and labor
- Indirect costs include corporate costs, monitoring and regulatory costs, and permit filing costs.
- Future/ Contingent costs include fines, remediation, and restoration
- Internal intangible costs include employee training and productivity costs (for example, a company with an undesirable environmental reputation might have higher employee turnover and/or attract less productive employees)
- External intangible costs include consumer perceptions, public relation and brand awareness

A source guide has been developed to facilitate data gathering by the collaborating firms; the collaborative tool development effort is in part a data-pooling exercise. Items are monetized where possible; however, the tool is targeted to inform management decision-making, and assessments of relative costs, risks and opportunities are readily employed in place of qualitative data.

For certain products, Monsanto has employed Ecobalance's LCA software to obtain ecological profiles for process inputs and products, getting eco profiles as far back upstream and downstream as possible. (In general, upstream information is of far higher quality.)

Perspectives on an EPR decision-support tool

In its collaborative total cost assessment tool development effort, Monsanto hopes to create a *de facto* industry standard for chemical process industries. For a decision-support tool to be useful to industry, it must be motivated by industry needs and designed by industry or with very close industry involvement — government sponsored or developed tools tend to be useful for regulators rather than

[17] E.g., "green" behavior might yield, higher bond ratings lower insurance rates.

the private sector. For managers to employ the tool rather than resorting to intuition, additional criteria are that the tool be:

- simple
- cost effective
- non perverse,
- integratable with other management tools,
- reproducible

These requirements are potentially conflicting and present a challenge to tool development. Modularity is a partial solution — developing discrete elements of a total tool which can be used as companies have a need for them (depending on product lines and areas of business). Flexibility is another partial solution — that is, allowing the tool to be modified to suit individual firm/line business requirements — so long as a minimum content and rigor are not sacrificed. Excess flexibility might allow companies to dilute or eviscerate the tool to the point of meaninglessness, while still claiming credit for practicing "green" decision-making.

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EPR Case Study: Nortel Networks

Company Overview:

Nortel Networks (Northern Telecom, previously T/A Nortel) provides digital network solutions in more than 150 countries and territories. It has approximately 80,000 employees worldwide, with 1997 net earnings of $957 million on consolidated revenues of $18 billion. Nortel Networks works with customers worldwide to design, build, and deliver communications and IP (Internet Protocol) – optimized networks by delivering integrated solutions spanning data and telephony. Customers include public and private enterprise and institutions; Internet service providers; local, long-distance, cellular and PCS (Personal Communication Services) communications companies; cable television carriers, and utilities.

EPR Activities:

Nortel's declared goal is to be an environmental leader within the telecommunications industry. Product Stewardship is a stated objective in the corporation's May 1996 Environmental Policy. Nortel describes its significant effort over the past several years to apply life cycle principles to manage the environmental impacts of its products and manufacturing processes over the whole of the product life cycle:

- **Design:** Nortel's Design for Environment (DfE) initiatives are targeted at introducing environmental concerns at early stages of product development. DfE Guidelines have been internally developed. Stated goals of DfE at Nortel are to create products that use fewer and more environmentally benign materials, increase energy efficiency throughout the product life cycle, use cleaner production practices and less packaging, extend product life, and provide for easy disassembly to recover and recycle materials and components.

  Nortel highlights its demonstration lead-free telephone as a DfE success with environmental as well as technical and economic payoffs. (Lead is a traditional component of circuit board solder connections.) Nortel believes its lead-free interconnect technology, for which R&D began in 1992, delivers an environmentally superior product while enabling the company to lower handling, liability and disposal costs.

  In early 1997, Nortel co-sponsored with Cable & Wireless Communications PLC the publication of "A Manager's Introduction to Product Design and the Environment," designed to provide a level of understanding for those involved in product development, marketing, and sales management to enable effective decision making about product design and the environment.

- **Materials Input:** Nortel's Supply Management division is planning to implement a "BuyGreen" program, with procurement guidelines aimed at providing direction for selecting and purchasing environmentally preferable products and services for the corporation. The stated intent is to prefer products and services that require fewer resources, use renewable and recyclable materials, and have a long use life.

  Nortel is working with the Chemical Strategies Partnership at an Ottawa facility to reduce chemical use and toxicity. CSP, a project of the Tides Foundation funded by the Pew Charitable Trusts and the Heinz Endowments, is managed by California Environmental Associates and the Tellus Institute. It aims to restructure the contractual relationship between customers and suppliers by developing performance-based incentives that reward suppliers for helping companies reduce chemical use.

- **Manufacturing:** In late 1991, Nortel became the first major electronics manufacturer to eliminate CFC-113 solvents from its manufacturing operations worldwide. Nortel has also developed a new chromate-free protective coating called "B2000", which is designed to replace the present industry standard and eliminate the environmental hazard of hexavalent chromium, a known cancer-causing agent.

- **Distribution:** Nortel has initiated a number of packaging efforts including: numerous reusable packaging systems; reducing the mix of materials to allow for easier recycling; and decreasing the weight of material-intensive crating.

- **Use:** Nortel has found that product energy use contributes the greatest environmental impact. Nortel states that it gives priority to increasing product energy efficiency by applying new design architectures, new component technologies, and power factor correction techniques. The company notes that its power supplies are now 90% efficient, improved from 75% energy efficiency 15 years ago.

- **End of Use:** Recovering and recycling Nortel products has existed in some form since the company began taking back old products from its customer, Bell Canada, in 1939. A recovery service was started in the U.S. thirteen years ago and in Europe three years ago. Products are remanufactured, resold, or recycled, depending on customer demand.

  In 1996, Nortel's material recycling facilities processed more than 22 million kilograms of equipment. Generating a significant economic return, the product take-back program is integrated into Nortel's business and has a significant presence. Nortel notes it is moving toward establishing a broader, corporate-wide product recovery program with BT and Cable & Wireless Communications in the UK.

Institutional and market context shaping EPR activities

EPR and product development

Product development at Nortel is conducted within product groups, which have "ownership" of a product from design to marketplace. Environmental considerations in design are introduced within the product groups, with the caveat that designers generally choose key aspect materials, components, and suppliers from approved lists generated by a product assurance and component engineering group. While internal DfE guidelines have been developed, there is currently little formal integration of environmental criteria into design at this line of business level. Rather, research and case-building activities for EPR are being conducted within the technology division and by the corporate environmental team. Individual EPR success cases and champions do exist within the business organizations, so now the environmental team feels it is in a position to begin working with business units to begin to "mainstream" EPR approaches.

- The corporate environmental team has focused on building the business case for pursuing EPR. This is a data-intensive activity, with a focus on quantifying costs and benefits, including the impact of legislative requirements (Europe) and market/customer preferences for "green" products (see following sections). The team has also focused on cultivating customer demand for environmental information, and improving environmental information provision to customers.

- The technology division has focused on researching life-cycle assessment (LCA) design tools and materials issues, cooperating with the corporate environmental team. This includes "Rapid LCA" tools (see below).

EPR Drivers

General managers of product groups are not currently (or in general) seeing strong incentives to practice DfE/EPR aggressively. Incentives that would induce an aggressive approach include customer requests (not yet a reality), the demonstration of economic and/or regulatory incentives, or product competitive advantages such as a reduction of time to market. Demonstrating the existence of such incentives constitutes, in essence, making the business case for EPR — a major goal of the corporate environmental team.

Regulatory incentives are a reality in Europe, where EPR-based legislation is increasing and already significant. It is easier to make the case in this market that aggressive EPR strategies offer a significant competitive advantage for the product.

EPR Barriers and Challenges

- **Culture change.** Moving from a compliance-based to a beyond-compliance, EPR-based approach to environment requires significant cultural change in Nortel, both at senior management levels and at the business level of product design/development. Effecting this change requires making the business case to support EPR activities on a cost/benefit basis. Barriers to achievement include lack of information and analytical resources and lack of successful cases as examples (a “chicken-and-egg” problem). Most of the points that follow in this section contribute to this “cultural inertia” as well.

- **Technology**. Design technology changes tend to incur high testing costs as telecommunications equipment is held to a very high standard of reliability. For example, in testing lead-free interconnect technology beyond prototypes, reliability testing in large field trials can be very costly. Combined with high levels of regulation which extend to materials choice, high costs of change contribute to significant institutional inertia against changing base technologies.

- **No uniform approach possible.** The lifespan of telecommunications products can vary from less than a year (phones) to several decades (transmission equipment). Thus, there is no uniform answer to focusing on design-for-disassembly/take-back (possible for short-lived products which contain useful components at end-of-life) versus recycling (more suitable for long-lived products likely to be obsolete upon retirement).

- **Focus on time to market.** The competitive environment in telecommunications and the rapid evolution of technology put a premium on achieving quick time-to-market. The introduction of environmental concerns into the design stage are seen as a source of potential delay at the line business level.

- **Less emphasis on hardware.** EPR opportunities largely lie in hardware design and manufacturing techniques. However, profit centers and business focus are increasingly seen to lie in software and networking services; attracting management attention to environmental issues consequently becomes more difficult.

- **Ability to influence suppliers.** Working with suppliers upstream and customers downstream is essential to making progress in extending the responsibility for products. However, Nortel’s customers and suppliers (such as microchip manufacturers) are often larger than Nortel, both in presence and in influence. (It was noted, however, that significant influence can be achieved with Nortel’s customers and in the supply chain, especially with smaller suppliers and those with whom Nortel has established a "value-managed"[18] relationship, where there can be influence through the sharing of information and technology.)

EPR information gathering

Making a business case for EPR has been a primary focus of Nortel's environmental team, an activity with significant information requirements. The team has been pursuing company-wide and case-specific cost-benefit analyses, attempting to assess costs and returns of environmental activity, the value of offering green products to key customers (or potential revenue lost by failing to do so), and the consequences of EPR-based legislation in Europe.

Accounting resources within the corporate environmental function are not sufficient for comprehensive treatment of these areas; data gathering infrastructure is likewise inadequate. Close work with relevant divisions and groups within the firm is thus critical. For example, Nortel's environmental team has conducted studies attempting to quantify revenue impacts of EPR legislation and market preferences for "green products" in Northern European markets. Sales and marketing teams worked together with the environmental division to gather information for making these business cases. Internal cost assessments, by contrast, are obtained from manufacturing and technology groups within Nortel. Historical cost information from similar types of environmental design activities, detailed and down to the design level, can be mobilized when assessing the cost of a green product yet to be designed.

Acquiring an environmental inventory of a product or potential product has been aided in many cases by Rapid LCA, a software-supported technique for assessing approximate material breakdown and energy consumption figures, using data gathered on a short (1-2 day) site visit at the relevant Nortel or supplier facility. This "quick and dirty" LCA could become the basis for a standardized assessment technique in the early product design process.

Perspectives on an EPR decision-support Tool

Having experimented with a number of products ranging from chips to telephones, Nortel has found that the scientific, full-scale LCA, which can take up to nine months, is too slow and too costly for use in the telecommunication industry, where products have to get to the market quickly and aggressively. Instead, checklists and basic principles like less energy, less material, recycling, etc., are used for life cycle assessment.

[18] A value-managed relationship involves an extra-ordinary agreement between Nortel and a company doing business with Nortel in which both entities have complimentary marketing and technological goals.

Since many of the currently available LCA tools are complicated, and resources are always tight, any new EPR decision support tool must be kept very simple, possibly as modules (a series of simple tools) rather than one single complex tool. It would include not only Rapid LCA, but also support for other elements of decision-making such as financial concerns.

Such a tool would be valuable for top-level decision-making – to help make the business case by disseminating environmental information, expertise and techniques. The tool would be needed at the concept stage to assist in answering questions such as "where does one start in creating an EPR product?"

Increasingly, services previously embodied in a product have the potential to be provided as a "pure" service — e.g., the replacement of answering machines with voice mail. An EPR tool which facilitates dematerialization— and which can assess environmental as well as economic implications — would be desirable.

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EPR Case Study: Safety-Kleen Corporation

Company Overview:

Safety-Kleen Corporation (SK) is an international industrial waste and environmental services company managing both hazardous and non-hazardous wastes. In 1998, Safety-Kleen merged with Laidlaw Environmental Services, forming Safety-Kleen Corporation. Safety-Kleen provides comprehensive waste management services to a wide range of customers, including recycling services for many small businesses. Safety-Kleen also provides a range of solvent and aqueous parts cleaning equipment, along with several waste water, fluid treatment, and silver recovery systems. These services are provided to over 400,000 customer in North America from 230 facilities. Safety-Kleen has over 11,000 employees world wide. In fiscal year 1998, Safety Kleen had a net income of $0.2 million on revenues of $1.2 billion.

EPR Activities

A primary Safety-Kleen service is the management of waste fluids, with preference given to reuse and recycling. Safety-Kleen is unique among the case study firms in that it provides "surrogate EPR services" as its primary line of business, generally to smaller firms and businesses without the resources to maintain a dedicated EHS staff member. Accordingly, this section provides a sampling of the most EPR-related of SK's service offerings, rather than describing EPR activities undertaken for its own manufactured products.

Representative service/product offerings:

- **Parts cleaner rental/servicing**. Safety-Kleen's original and core business is the "sink on a drum" parts cleaner, which recycles solvent for the cleaning of parts in a variety of assembly and repair shop settings — e.g., auto, bicycle repair shops, print shops, industrial facilities. Safety-Kleen rents and services the cleaner, and provides and reclaims the solvent. SK "closes the loop" by recycling the solvent in its hub facilities. The parts cleaner technology was modified in 1993 to employ cyclone separation during use, reducing solvent demand and extending service intervals.

- **Used oil collection and re-refining**. Safety-Kleen has a closed loop oil re-refining business which removes used motor and lubricant oil from businesses (primarily service stations, auto repair shops & industrial sites), re-refines it, and markets the resultant product both to take-back sites and on a retail basis. Safety-Kleen possesses 80% of North America's total re-refining capacity; only about 10% of used oil generated in the North

American market is re-refined. (The majority is burned as fuel, the rest discharged to soil or water.)

- **Dry-cleaner service.** Safety-Kleen provides filter and sludge removal and recovery services to over half the dry cleaning establishments in the U.S. (company figures). Safety-Kleen states this resulted in the recovery of 600,000 gallons of dry cleaning solvents for reuse in 1994.

- **Environmental cost accounting and integrated compliance.** Safety-Kleen performs, via a several-day site visit, a rough total environmental cost accounting for its small industrial customers. SK uses this assessment as the basis of formulating a services bundle for the customer which should reduce their costs and increase compliance. SK also provides on-site training and compliance auditing.

Institutional and market context shaping EPR activities.

EPR and product/market development

As noted above, contract EPR services are Safety-Kleen's primary products. Product development for SK thus means making the business case to develop such an EPR service and consists of quantifying internal costs and assessing demand.

SK's focus on service provision provides incentives for SK to reduce virgin inputs and preserve natural resources. For example, solvent recycling from SK's core and original parts cleaner business was motivated by the cost pressures created by providing virgin solvent with each service call. This focus also provides incentives to educate customers regarding their environmental costs; when total costs are understood, SK feels it will generally be able to offer savings compared to the firm's current real costs. SK works closely with trade associations to inform particularly small businesses (e.g., drycleaners, automobile dealerships, auto repair shops) regarding their environmental costs and compliance.

SK notes that it chooses to manage wastes as much toward the top of the reduce/reuse/recycle hierarchy as possible, compared to other waste services providers. This leverages its reverse distribution network and technical competencies, as well as providing a value-added service for environmentally conscious customers.

EPR drivers

Note. EPR drivers identified here are market factors which create direct demand for SK's services and products. This stands in contrast to other case studies which identify drivers to integrate with/augment EPR services with existing products.

- **Regulations**. The liabilities and costs which environmental and occupational regulations attach to waste chemicals create in largest part the demand for SK's services. This has a number of aspects:

    a) The complexity of the regulatory environment means that many small firms do not have the internal resources/knowledge required to act in compliance, creating a need for SK as a provider of specialized expertise and services.

    b) Liabilities established by CERCLA create a willingness to pay a premium for waste services of assured quality; SK provides waste generators cost indemnification against CERCLA liabilities for incidents occurring while the waste is in SK's possession.

    c) Federal purchasing of recycled products (1993 Executive Order) has created direct and spillover demand, as has an increasing regulatory emphasis on pollution prevention and reuse over end-of-pipe approaches (e.g., the Pollution Prevention Act of 1990).

- **Costs**. Where SK can make a case to a business that SK's services deliver bottom-line benefits, this is a powerful inducement to the customer. In general, making this case is contingent on the business having some idea of the costs it currently incurs for environmental management. SK attempts to help customers understand these.

- **Green consumer preferences/corporate green commitments.** SK notes that some firms are willing to pay a premium for waste management services which operate farther up the reduce/reuse/recycle hierarchy than those offered by other providers. The company also identifies public demand for green products and business practices as driving demand for certain of its products (e.g., re-refined oil) and services.

- **Strategic fit with manufacturer's EPR needs**. SK notes that it is engaged in a number of product stewardship agreements with manufacturers such as Kimberly-Clark, Konica USA, 3M, Amoco Lubricants and Castrol for the recovery of used and off-specification product. These agreements leverage SK's reverse distribution system against these manufacturer's EPR needs.

EPR barriers

Note. "EPR barriers" presented here are barriers SK faces in expansion and operation of its business and in making a successful "sell" for its services. This is again in contrast to other case studies, which generally describe internal and market barriers to the pursuit of EPR activity in the context of existing products.

- **Regulations.** Although regulation creates much of the demand for SK's services, SK also argues that the reduce/reuse/recycle hierarchy and SK's market opportunities are undermined by perversities in major regulations: For example,

  a) EPA's used oil regulations provide equal preference for burning used oil (energy reclamation) and re-refining (recycling/reuse), and permit blending used solvent with this oil for use as fuel. This reduces incentive for firms to pay for take-away recycling services.

  b) Treatment of materials designated as hazardous waste under RCRA and other statutes can make product reclamation for recycling or take-back prohibitively difficult.

- **Separation of functions/little integrated understanding of environmental costs**. Where firms have little integrated grasp of their environmental costs, the apparently larger cost of an environmental services provider (e.g., Safety-Kleen) is hard to justify. Likewise, division of purchasing/operation and disposal functions within an industrial operation often means that the cost savings which SK can offer may depend on cooperation between plant functions which does not exist or is difficult to achieve.

- **Cost**. SK is generally not the lowest-cost provider of a waste service, and must compensate by providing more comprehensive/reliable/value-added service.

- **Quality perceptions.** Recycled products —particularly re-refined oils — have met with significant quality perception issues in the marketplace. SK attributes these to industry experience with an earlier generation of re-refining processes which did in fact produce lower quality product. SK describes significant effort devoted to certifying its re-refined product with standards organizations and major equipment manufacturers.

EPR information-gathering

As described above, via test-marketing and pilot projects, SK gathers internal cost and market demand information in its product development process. Because internal costs are the costs (and overhead) SK incurs in reverse distribution and regeneration and/or disposal of waste, much of SK's business cost accounting is in reality TCA.

SK recognizes that greater appreciation of environmental costs on the part of its customers and potential customers creates higher demand for its services.

Perspectives on an EPR tool

Because of the link between customer awareness of environmental costs and demand for SK's services, SK believes there is a significant role for streamlined tools which (1) allow small firms to understand their environmental costs and (2) facilitate evaluation of how those costs would change given the pursuit of a number of possible product stewardship paths. This reflects cost reduction as the primary driver of EPR activities.

Additionally, SK could well have use for such a tool, both in building cost models for its own product development efforts, and as a tool for customer education.

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EPR Case Study: SmithKline Beecham

Company Overview

SmithKline Beecham (SB) is a multinational pharmaceutical and health care services company. The firm develops, manufactures and markets pharmaceuticals, vaccines, over-the-counter medicines and health-related consumer products. Health care services include disease management, clinical laboratory testing, and pharmaceutical benefit management. Some of SB's over 400 branded products include Seroxat/Paxil, a leading antidepressant; Augmentin, a leading antibiotic; Aquafresh toothpaste;, and NicoDerm CQ and Nicorette, SB's smoking cessation patch and gum.

SmithKline Beecham employs 58,000 worldwide and operates 90 manufacturing and clinical laboratory facilities in over 30 countries. Net income in 1997 was $1.65 billion on worldwide sales of $12.78 billion.

EPR Activities

SmithKline Beecham's corporate environmental policy includes commitments to continuous improvement and to "ensure that its products and their manufacture will not be harmful to people or the environment,"[19] but not explicitly to EPR or life cycle-based approaches. SB's EPR activities fall under the firm's product stewardship initiatives:

- SB notes that a significant focus of its product stewardship efforts is directed towards information provision for safe and environmentally responsible product manufacture and use, inside and outside the company. These include general and technical product stewardship guides (the latter for use inside the manufacturing organization) as well as usual MSDS development and provision.

- SB developed an internal Solvent Selection Guide, currently covering 35 solvents, to provide single-source information on organic solvents to research chemists and engineers, who can assess the environment and safety implications of different solvents and make selections early in the product development process. The environment and safety implications associated with the use of each solvent are rated within the following categories: ease of incineration, ease of recycling; biotreatability, potential for volatile organic compound (VOC) emissions, impact on water, impact on air, health hazard, exposure potential, and safety hazard.

[19] SB *Environment and Safety Report*, 1997

- SB recently developed its "Environment and Safety Process," (ESP) designed to "integrate environment and safety into all stages" of SB's newly streamlined product development process. ESP covers environment and safety hazard determination, evaluation, and risk assessment, occupational exposure standards and protocols, occupational hygiene methods development, environmental hazard assessment concentrations and protocols, technology transfer from R&D to production, EHS evaluation of plant and engineering design, and environmental and safety permitting.

- As the industry increasingly employs contract/third-party manufacturing, SB has developed a contractor operations management system which implements an SB Environment and Safety Standard committing SB to ensuring contract manufacturers maintain SB's level of environment and safety standards.

- In development is an internal Green Chemistry awards program; SB also participates in external Green Chemistry initiatives and research efforts.

- SB describes efforts to reduce packaging volume and improve its recyclability. Several in-house design tools have been developed to aid this effort.

Institutional and market context shaping EPR activities

EPR & the organization of product development

SB is employing life cycle assessment (LCA) to identify environmental priorities. The solvent selection guide (above) was the outcome of such an effort, as is its successor project which will provide an environmental sourcebook for green chemistry. These projects have operated within SB's Environmental Product Stewardship Group, a strategic team within the Corporate Environment and Safety Department. In building support for more aggressive stewardship activities within SB, the Product Stewardship Group has focused on building the business case for these activities.

Currently, SB employs a checklist-based approach (see ESP, above) in trying to ensure that product development takes into account environment and safety issues. This is, however, not universally applied and remains a very basic approach (costs are not included in the assessment). SB's stated commitment, however, is to integrate environment and safety/life cycle concerns across business areas, including capital review, sourcing, contract manufacturing, etc.

Towards this end, SB is engaged in a collaborative effort with AIChE (American Institute of Chemical Engineers) Center for Waste Reduction Technology and a set of nine large chemical process-based manufacturers to develop a comprehensive total cost accounting (TCA) tool. The tool development includes multiple pilots by participating collaborators to rigorously test the methodology and allow the development of company-specific data sets which may be internally benchmarked. Costs considered include "future and contingent, internal and external liability costs associated with products and processes,"[20] including a limited set of environmental externalities. (The tool does not consider supplier-related impacts). The effort is expected to produce a software-based tool; currently, the tool is in paper and spreadsheet-form. SB will modify the tool for internal use, specifically hoping to provide R&D with a means to evaluate alternative processes from a total cost perspective at the earliest stages of development. The point-of-contact for TCA tool development has also been the Product Stewardship Group.

EPR drivers:

- **Previous experience**. Nearly 20 years, ago, SB had the experience of developing a significant product which created large and unexpected environmental problems for its manufacturing facilities. This provided significant incentive to think systematically about examining environment and safety issues at an earlier stage in the product development process.

- **Corporate image and perceived trends**. There is to some degree (not universally shared) a belief that in the future the business environment will be increasingly characterized by cost internalization and required product stewardship/EPR activities. Proactive stewardship/EPR programs are thus part of a strategy for long-run competitiveness. Presently, "green" corporate behavior does have value in terms of community and regulator relations, and to some investors, even if not explicitly employed to sell products.

- **Continuous environmental improvement as efficiency driver**. SB has implemented a number of process changes with significant savings in waste management costs. Although these are not demonstrably direct results of product stewardship per se, these changes nonetheless demonstrate a tangible relation between process changes and bottom line costs of waste management. This helps make a necessary business case for stewardship activities.

- **Corporate commitment**. As a signatory of the ICC Business Charter for Sustainable Development, and in its Environmental Policy, SB states that it recognizes and accepts its obligation to move its environmental activities "beyond compliance."

[20] AICHE project description. Project Title "Total Cost Accounting"

EPR barriers:

- **Generational change required**. Moving from a compliance-based to a beyond-compliance, stewardship- or EPR-driven approach requires significant cultural change in SB, particularly in middle management. Strong business cases must be made for stewardship activity, establishing it as multi-disciplinary, multi-site, multi-benefit initiatives that demonstrate a clear connection between stewardship and the bottom line.

- **Data/tool availability**. A major reason for engagement in the collaborative TCA tool development effort described above is lack of current integrated data and tools to make cost-based assessments of EPR activities.

- **Dominance of product rather than environmental liabilities**. For pharmaceuticals, product liabilities dwarf environmental liabilities, which makes it more difficult to argue the business case for pursuing environmental stewardship. In the future, the significance of environmental costs to the industry is likely to be a function of the costs of current externalities (e.g., CO_2 emissions.)

EPR information gathering

As noted above, data/tool availability is an impediment to the practice of Stewardship/EPR at SB. The collaborative TCA tool development is in part a data-pooling opportunity — data included in this effort includes risk, liability, probabilistic estimations, existing data on fines and penalties. Though less clearly developed currently, in the future it would also incorporate estimated externalities.

Extending LCA beyond the current bounds of the TCA tool — that is, looking at upstream life cycle impacts of feedstocks — is a challenge. With exceptions for certain bulk chemicals (e.g., hydrochloric acid, solvents), upstream life cycle data for the specialized intermediates used by pharmaceutical and specialty chemical firms is sparse. In its internal LCA efforts, the Product Stewardship Group has employed a variety of approaches to garner this upstream data, including generation *ab initio*, or from the "nearest neighbor," or closest approximation. For downstream (post-manufacturing) impacts, SB plans to examine internal cost and liability data.

Perspectives on an EPR decision-support tool

SB hopes that the TCA tool in whose development it is collaborating will become a *de facto* industry standard, in large part because its development has been industry-driven and specifically geared to the needs of chemical process-based industries. This type of comprehensive TCA approach, however, is one likely to be undertaken only by large firms with the corporate resources to support the effort required. Though the tool is intended to be modular and tiered, permitting small and medium-sized firms to "pick and choose" cost areas and levels of cost detail they would pursue, there might well be a need for a "canned" and streamlined LCA/TCA tool for use by smaller firms.

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EPR Case Study: Xerox

Company Overview

Xerox Corporation produces copiers, printers, fax machines, scanners, desktop software, digital printing and publishing systems, and supplies. Marketing itself in recent years as "The Document Company™," Xerox offers comprehensive document-management services. With 91,000 employees, Xerox operates 29 manufacturing sites in 14 countries. 1997 net income was $1.45 billion on revenues of $18.2 billion.

EPR Activities

Xerox's corporate environmental policy pledges the company to several EPR-related principles — particularly, commitments to continuous improvement, and to the design, manufacture, distribution, and marketing of products and processes to optimize resource utilization and minimize environmental impact.

Xerox distinguishes between the company's pre- and post-1990 approaches to environmental policy. 1990 marked the start of the company's Environmental Leadership Program, in which the company stated a commitment to a beyond-compliance environmental leadership, with foci on product stewardship and eco-efficiency ("Waste-Free products in Waste-Free factories").

Example of EPR activities include:

- **Design for Environment**. DfE initiatives and guidelines support both reduction of environmental impacts associated with product use (energy, emissions) and end-of-life issues (disassembly, material recycle, part remanufacture). DfE guidelines and procedures adopted include snap-together designs, recycled material guidelines, remanufacture part coding, etc.

- **Consumable product take-back**. Launched in 1991, Xerox's worldwide Copy and Print Cartridge Return Program allows customers to return spent copy and print cartridges in the original packing materials (or packing for replacement parts) via a supplied, prepaid return label. The cartridges are cleaned, inspected, and then refilled or recycled. The program has a worldwide return rate of more than 60 percent. A toner container recycling program was initiated in 1995, and waste toner return program in 1997.

- **Durable product take-back and remanufacturing**. Xerox has made a significant commitment to remanufacturing and recycling end of life products, with a stated goal of zero waste to landfill. Dedicated recycling centers receive and strip end of life machines; remanufacturing is conducted on Xerox's assembly lines. 30,000 tons of machines are reclaimed each year.

Institutional and market context shaping EPR activities

EPR and product development

Xerox describes a product development ("Time to Market") process which integrates environmental, health, and safety (EHS) concerns/Design for Environment (DfE) in support of the waste-free products concept. Required training for design engineers at Xerox includes environmental design criteria. Product development occurs within cross-functional teams headed by a program manager; these teams include a remanufacture engineer, as well as an EHS engineer. DfE criteria are incorporated into product specifications and products are evaluated against these criteria before a prototype can move to the demonstration state. Criteria include recyclable/recycled materials content, minimization of in-use emissions, and remanufacturability; these are incorporated into Xerox's multinational design standards for environmental and remanufacturing design.

Xerox's EPR initiatives, beginning at the concept and product design stages, rely on tight integration with suppliers, who supply not just raw materials, but components. Xerox thus must rely upon them to remanufacture disassembled parts, as well. As part of this integration, Xerox provides suppliers with proprietary "signature analysis" technology used to determine the amount of useful life left in parts and assemblies. Materials use is an additional area requiring close communications.

EPR Drivers

- **Regulation.** Xerox's take back measure was incorporated as a business concept in 1990 and formally implemented in 1991. Thus, as it was initiated before regulations were implemented, the program was not regulatory-driven. However, Xerox states that early and proactive movement in this area in anticipation of regulation is a likely source of competitive advantage.

- **Customer demand/loyalty.** Where customers are concerned about their waste streams, customer demand plays some role in the development of product take-back programs for consumables and packaging. Some "green" product demand also exists, providing impetus for developing products with superior environmental performance — particularly as certified by ecolabeling schemes — in the areas of energy use, emissions, and recyclability

- **Economic reward.** In certain cases, recycling and reuse can result in substantial savings; understanding these savings, however, is contingent on accounting for costs and benefits across the company and over time.

- **Shift toward service orientation.** As a company, Xerox has been repositioning itself towards document services provision ("The Document Company™") rather than a manufacturer of copiers. This servicizing shift has, in a general way, been of benefit to EPR activities, which are in part the provision of services (e.g., take-back) piggybacked onto existing products.

- **Corporate commitment**. EPR activities are consistent with Xerox's stated commitment to beyond compliance environmental leadership.

EPR Barriers

- **Economic viability**. Making the business case that an EPR initiative is sound is a necessary prerequisite to its implementation. However, an overly narrow assessment of the bottom line, either (1) by ignoring intangibles or (2) by failing to consider costs and benefits over the full life cycle and across the company, can screen out sound initiatives. With respect to intangibles, for example, Xerox loses money on its toner containers recycling program, but the company believes the returns in customer satisfaction more than compensate.

- **Accounting systems, internal distribution of costs and benefits**. Accounting systems which do not consider costs and benefits over the full life cycle and across the company can be significant EPR barriers. For example, in designing products with extended and multiple lives, the costs of original parts are typically increased. If the recovered value of these parts is not considered, the EPR effort will appear unattractive. Similarly, costs and benefits of EPR activities are not distributed evenly across divisions. The additional design burden in cost and time represented by environmental design criteria is borne by design groups, while the manufacturing division gets the benefit and credit when products are recovered.

- **Customer perception and contract requirements**. Customer perception that remanufactured products are of lower quality (or, alternately, should be cheaper) has been an obstacle. The government market can present a further obstacle, as procurement requirements — particularly in the state and local level in the U.S. and some European countries such as Germany — can specify that "new" products be made with virgin parts. This makes the marketing of recovered products difficult and is a disincentive for recycling.

- **Regulation.** Though European regulation with respect to product take-back is an EPR incentive, European regulation regarding trans-boundary shipment of end-of-life equipment may be a significant obstacle. Specifically, components that are considered regulated materials must be removed before shipment. This has the potential to conflict with the take-back infrastructure which Xerox has established which utilizes central disassembly facilities, although this currently is not a problem.

- **Focus on time-to-market.** Technology in document management advances rapidly — the more so as products become increasingly digital — putting pressure on product divisions to move a product rapidly to market. The perception exists that the addition of environmental criteria to design represents a source of potential delay in the development process.

- **Data availability.** Data for assessing life cycle costs associated with different EPR options can be difficult to gather.

EPR information gathering

To assess the costs and benefits of EPR initiatives, Xerox evaluates external influences (customer demand, competition, technology and regulatory trends), life cycle inventory data, and internal costs (manufacturing and materials costs), and the implications of these for product pricing.

Much data is obtained within Xerox. Within Xerox, EPR cost information is usually assembled by the design team, headed by the program manager, which collects and reviews information regarding EPR, including materials, recycling and remanufacturing costs (the design teams include accounting support). This information usually resides within the design community itself or within the standards group.

Other data must be obtained from materials and components suppliers. Xerox usually goes to its 1st tier suppliers, except for plastic suppliers, in which case Xerox would interact with both molders (1st tier) and resin suppliers. Xerox's suppliers, in turn, go to their own suppliers to obtain data.

Collecting data for life cycle assessment can be challenging: LCA data are not currently well-developed. Xerox employs streamlined LCA, focusing on those life cycle elements and product attributes with the largest environmental impacts. For example, the most significant environmental impact of copiers is the paper and energy use during the product-use stage of their life cycle. Xerox uses Ecobalance's TEAM database software (using industry average data) and then collects additional data if necessary.

End-of-life costs can be likewise problematic. While the transportation costs of product take-back are well accounted for, costs in the later reuse and remanufacturing process are more difficult to quantify.

Perspectives on an EPR decision-support tool

Xerox has experimented with a number of tools to support DfE/EPR activities. Among these are:

- a financial model which examines life cycle costing associated with different design options, based on tools which examine net present value for parts with multiple lives. (If a design has an environmental aspect to it, Xerox typically uses a longer time horizon to assess its profitability.)
- Ecobalance's TEAM software for LCA
- Software to optimize design for disassembly and recovery

Based on experience with these tools, likely users for a more integrated or additional EPR decision-support tool would be the design team and EHS staff. Extensive data input requirements will tend to make a tool overly burdensome in use; on the other hand, the value-added of an integrated tool would be to link life cycle assessment data with real economic costs and to integrate this with Xerox's financial and accounting systems. These are somewhat contradictory requirements, and seem to require a specialized tool.

It seems unlikely that a tool could contribute usefully to the forecasting and assessment of key external factors important to Xerox's decision making, such as anticipated regulatory and market trends, technology evolution, and the actions of competitors.

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APPENDIX B: EXAMPLES OF EPR-RELATED TOOLS

A few examples of software based tools in the three categories most related to the environmental aspects of EPR decision-making are given below.[21] The products listed are neither endorsed nor exhaustive:

Life Cycle Costing and Impact Analysis		
EPS Enviro-Accounting Method	Swedish Environmental Research Institute; Swedish Federation of Industries	Environmental Impact Analysis for product/process comparison. Uses a monetized valuation scheme to assess changes in key metrics arising from a product/project (i.e., human health, biodiversity, production, resources, aesthetics). Valuation is based on willingness to pay.
TEAM/DEAM	Ecobalance (Ecobilan)	TEAM software generating life cycle inventories and life cycle costs, including sensitivity analysis. DEAM database includes LCA profiles of products & processes.
Waste Reduction Software		
P2P	National Risk Management Laboratory, USEPA	Software system for measuring progress in pollution prevention achieved form a single project involving redesign, reformulation or replacement. Progress is measured by releases to different media and three impact categories.
SWAMI (Strategic Waste Minimization Initiative)	Developed for EPA by PEER consultants and University of Dayton Research Institute	Software takes user-supplied process information to identify pollution prevention opportunities within an industrial setting. Employs mass balance and process flow in process analysis.
Design for Environment Tools (availability unconfirmed)		
EIME	Ecobilan (Ecobalance)	Integrates Ecobalance's database with an analytical approach which divides the product into components which can be discretely analyzed and impact analysis performed in terms of 12 environmental impact categories.
EcoDesign Tool	Design for Environment Research Group, Manchester Metropolitan University	Active software agents provide environmental design guidance to product engineers; integrated into CAD environment.

Figure 6: Tool Examples

[21] These descriptions are taken from the survey report *Incorporating Environmental Costs and Considerations into Decision-Making: Review of Available Tools and Software* (EPA, 1996) and *Ecotools manual — A comprehensive review of Design for Environment Tools, (*Nils de Caluwe, Design for Environment Research Group, Manchester Metropolitan University, 1997).